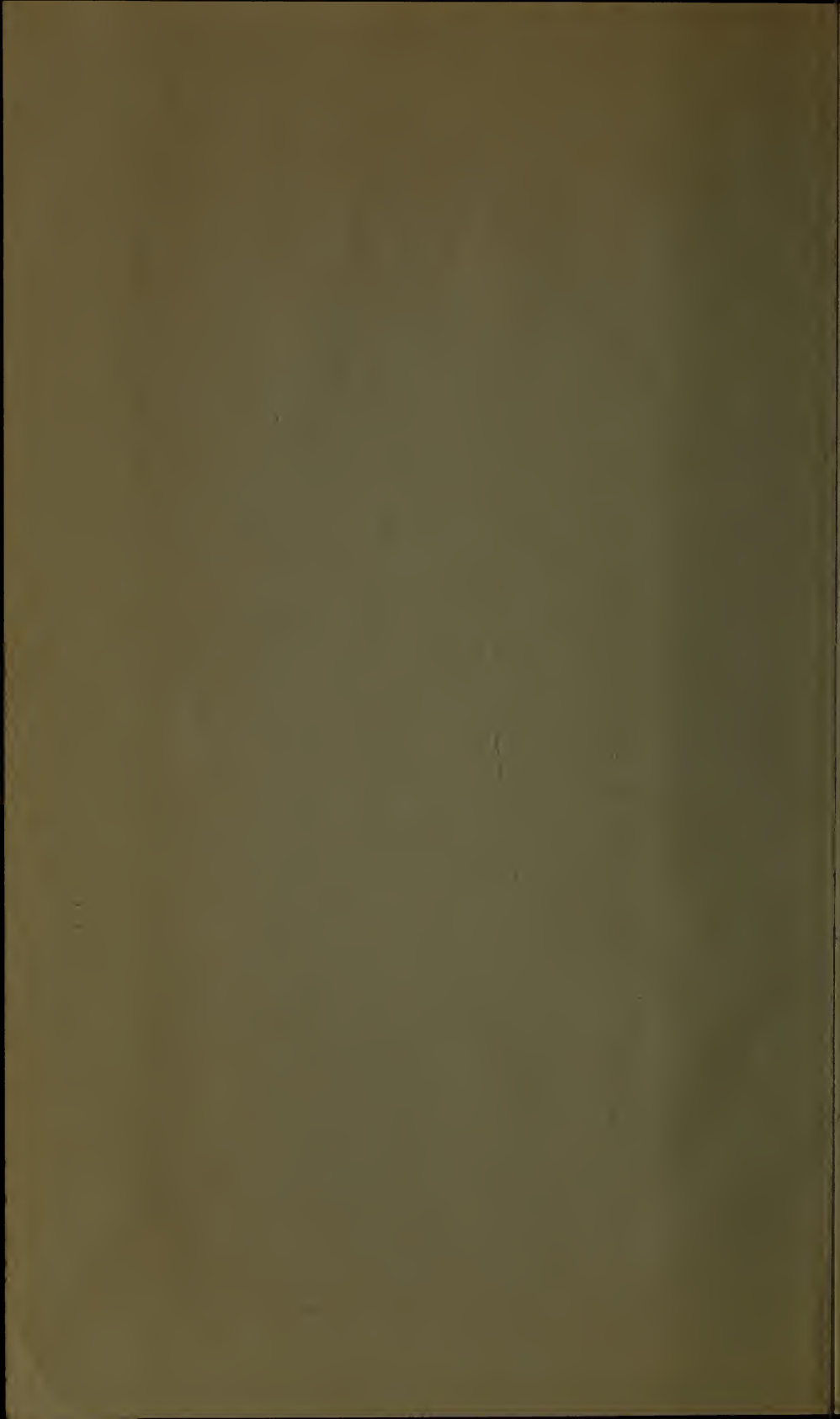
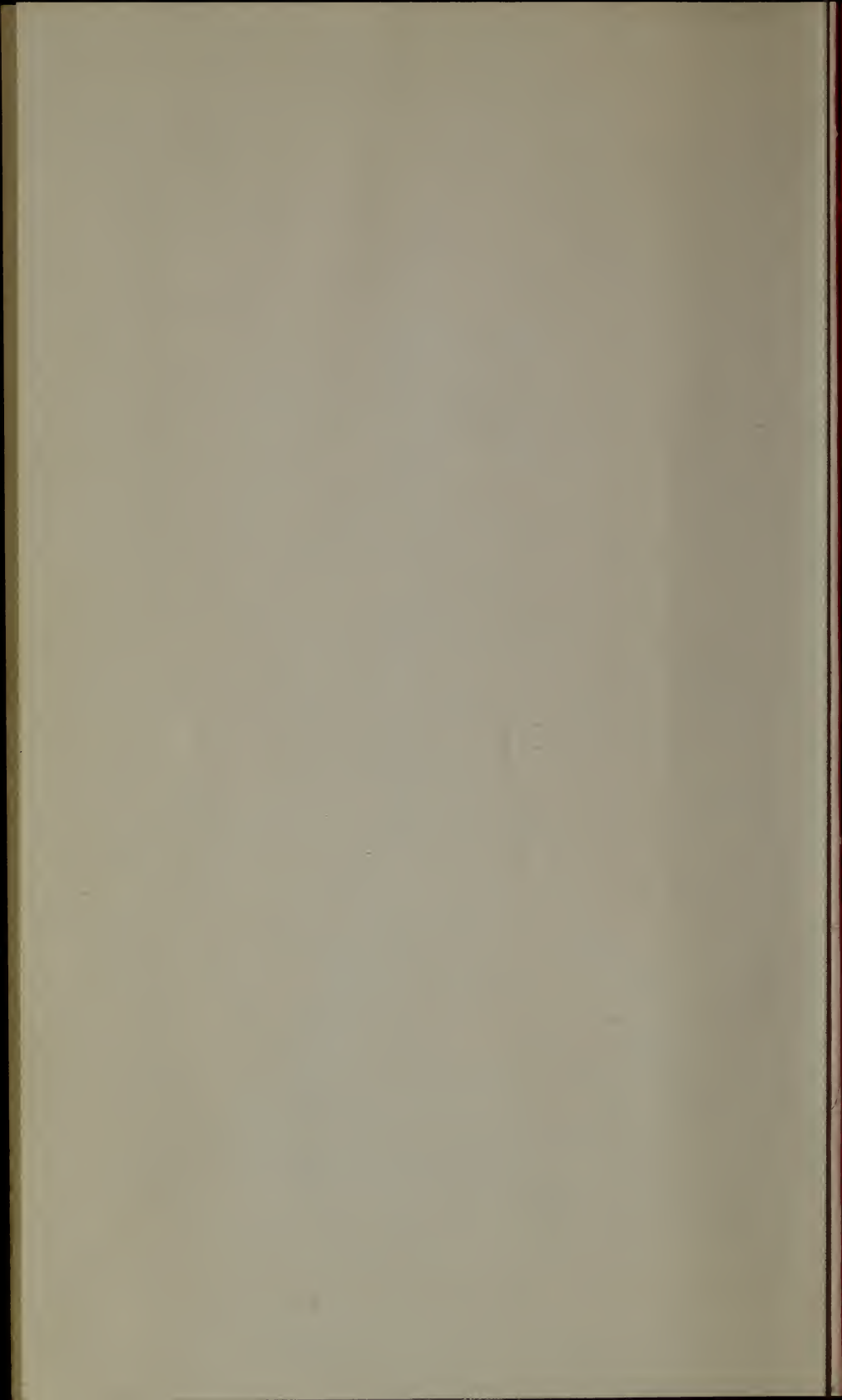


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by LTI, therefore, not included
in this volume.



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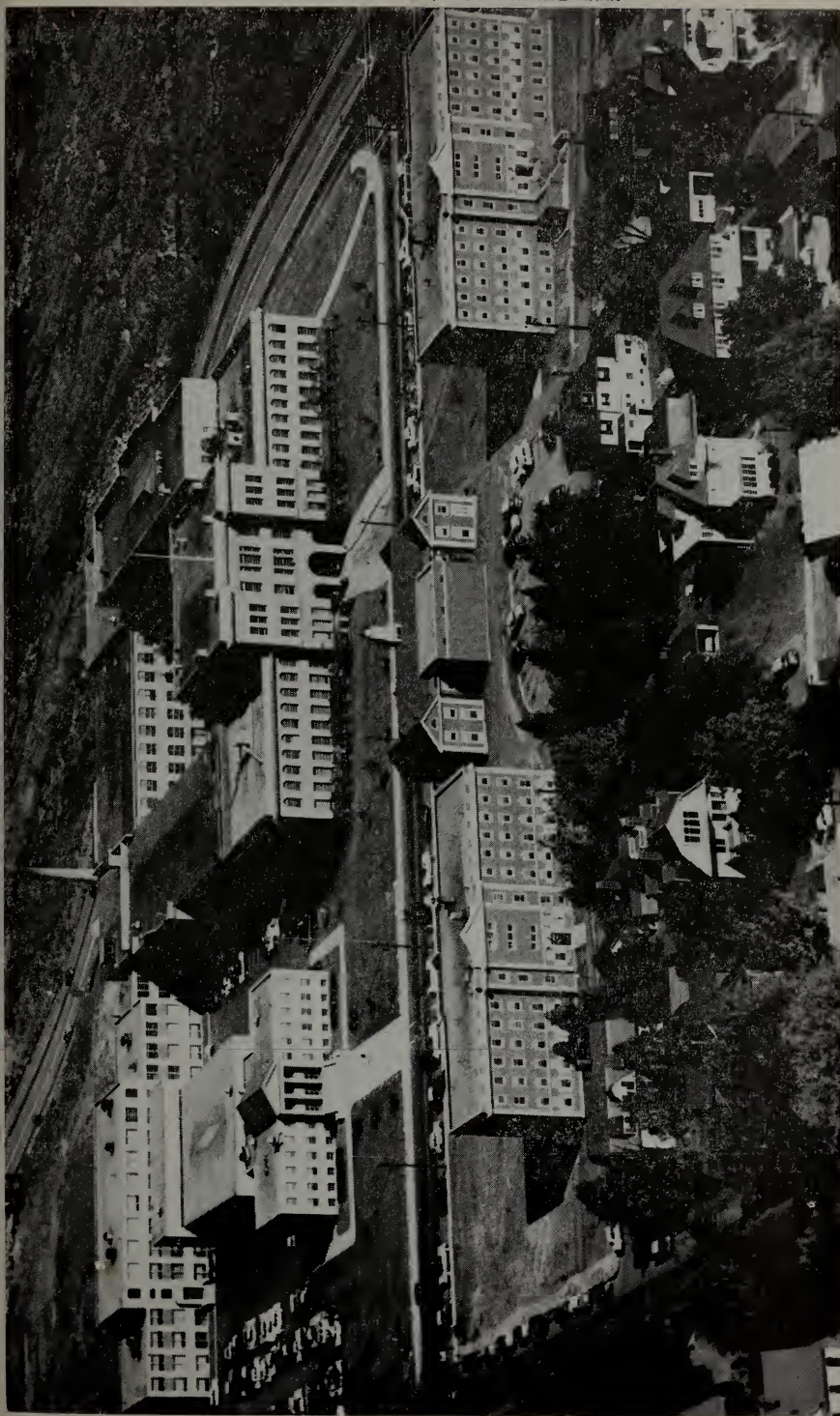
LOWELL TECHNOLOGICAL INSTITUTE

CATALOGUE ISSUE

1959-1960

Special SCIENCE COUNT-DOWN Edition

The Board of Trustees of the Lowell Technological Institute voted to publish this special SCIENCE COUNT-DOWN edition of the college catalogue as an integral part of its program of scientific and technological education. The SCIENCE COUNT-DOWN 1959 project has been sponsored by the Institute for the purpose of stimulating an awareness among the young people and parents of the Commonwealth of the importance of a knowledge of the basic sciences. In cooperation with WBZ-TV, Boston, the Institute inaugurated in February, 1959, a state-wide science quiz for all students in the eighth grades of public, parochial, and private schools. After the elimination contests, the pupils selected as county winners appeared in a weekly series of live telecasts culminating in a grand final "count-down," which, in effect, resulted in the selection of the outstanding "junior scientist" in the Commonwealth of Massachusetts. The Trustees feel that this pioneering project in the field of education has great potentialities for enhancing the intellectual curiosity of the young people of the state with especial reference to the field of science, and they trust that, through this Bulletin made available for general distribution, the beneficent effect of SCIENCE COUNT-DOWN 1959 may be extended indefinitely.



Aerial View of the Campus



Reading Room of the Library

BULLETIN
of the
Lowell Technological Institute
LOWELL, MASS.

Published Quarterly

1959

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The Institute reserves the right to make changes in the regulations, courses, and charges announced in this Bulletin.

INSTITUTE CALENDAR

FOR

ACADEMIC YEAR 1959-1960

September 8, Tuesday	Freshman Orientation Week begins.
September 14, Monday	Registration of seniors and juniors.
September 15, Tuesday	Registration of sophomores and graduate students.
September 16, Wednesday	Classes begin.
September 23, Wednesday	Last day to register for new classes.
October 12, Monday	Columbus Day. Institute closed.
October 13, Tuesday	Last day to drop classes without penalty.
November 11, Wednesday	Veterans' Day. Institute closed.
November 25, Wednesday, 1 P.M.	Thanksgiving recess begins.
November 30, Monday	Classes resume.
December 18, Friday, 5 P.M.	Christmas recess begins.
January 4, Monday	Classes resume.
January 11, Monday	First-semester examinations begin.
January 23, Saturday	First-semester examinations end.
February 1, Monday and	Registration of all students.
February 2, Tuesday	
February 3, Wednesday	Classes begin.
February 10, Wednesday	Last day to register for new classes.
February 22, Monday	Washington's Birthday. Institute closed.
March 1, Tuesday	Last day to drop classes without penalty.
April 8, Friday, 5 P.M.	Easter recess begins.
April 20, Wednesday	Classes resume.
May 18, Wednesday	Second-semester examinations begin.
June 3, Friday	Second-semester examinations end.
June 5, Sunday	Baccalaureate and Commencement.

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ELIZABETH P. KENNEDY	<i>Office of the President</i>
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MONA M. DAVIS	<i>Division of Chemistry</i>
BARBARA JEAN MACCARON	<i>Office of the Dean of Students</i>
ELEANOR M. McKENNA	<i>Division of Engineering</i>
ROSEMARY CAMBRIA	<i>Office of the Bursar</i>
HARRIET R. DALY	<i>Division of General Studies</i>
E. JOYCE ENIS	<i>Division of Engineering</i>
DORIS A. GAGNON	<i>Office of Special Services</i>
PATRICIA J. GALLAGHER	<i>Office of the Bursar</i>
BARBARA M. JAROS	<i>Office of the Bursar</i>
CHARLES F. JOHNSON	<i>Office of the Bursar</i>
LORRAINE I. LEDOUX	<i>Office of the Registrar</i>

NORA M. MACBRAYNE
ESTHER M. MCKINLEY
MAUREEN S. NAZE
CATHERINE P. OUELLETTE
LILLIAN R. PERRY
JOHN L. SAYER
JOYCE A. SULLIVAN
JANE M. TEAGUE

Buildings and Power

GEORGE F. ABODEELY, LL.B.
RALPH E. FROST
JOSEPH A. NERNEY

Office of the Registrar
Division of Textiles
Receptionist
Office of the Bursar
Office of the Registrar
Office of the Bursar
Office of the Bursar
Office of Admissions

Administrator
Chief Engineer
Maintenance Foreman

ALUMNI ASSOCIATION

Objectives of the Alumni Association are to advance the interests of Lowell Technological Institute, to secure systematic and unlimited gifts thereto and to receive and hold money and property, both real and personal, and to manage, use, and dispose of the same as appears to be in the best interests of the Institute.

All students of the Institute who have completed satisfactorily at least one year of the day curriculum are eligible for active membership. Only the active members have the right to vote and hold office in the Association.

The by-laws of the Association also provide for Honorary and Associate memberships. The Honorary Membership, Scroll, and Citation may be awarded by the Board of Directors to any person who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to Associate membership by the Board of Directors. The Honorary Award, Scroll, and Citation may be awarded by the Board of Directors to any active member of the Alumni Association who has made outstanding contribution to the arts or sciences.

The Association administers numerous scholarships and fellowships; publishes the official alumni magazine, "The L.T.I. Alumni Bulletin"; publishes an Alumni Directory; aids student organizations; and performs the numerous functions normally associated with alumni organizations. Membership is held in the American Alumni Council. The Association holds its annual business meeting and banquet in the spring of each year.

Communications should be addressed to Professor A. Edwin Wells, Executive Secretary, Alumni Office, Lowell Technological Institute.

Officers

CLIFFORD A. HARVEY, '49, *President*

HAROLD L. PECKHAM, '17, *First Vice President*

HERBERT W. WILKINSON, '37, *Second Vice President*

A. EDWIN WELLS, '20, *Clerk, Treasurer, and Executive Secretary*

ROBERT E. MORRISON, '51, *Assistant Secretary*

EUGENE F. CRANE, '33, *Chairman of the Fund Council*

RESEARCH FOUNDATION

In recognition of the unique research opportunities afforded to industry by virtue of the equipment and staff available at Lowell Technological Institute, the Massachusetts State Legislature in November, 1950, authorized the establishment of the Lowell Technological Institute Research Foundation. Its purpose is to conduct research, development, and consulting programs under contract with responsible agencies and industrial organizations. This activity has the effect of permitting staff members access to new and significant developments in industry and materially assists in keeping the teaching programs current and dynamic.

The Research Foundation provides the necessary mechanism whereby all of the research work of the Institute is brought under one coordinating office headed by the Executive Director. As in the past, however, the faculty of the Institute does the greater part of the research work. This plan has been proved through years of experience to be highly beneficial to the Commonwealth, to the Institute and to industry.

The Foundation has the use of the Institute's laboratory and research facilities in chemistry, physics, engineering, textiles, electronics, paper, leather, and plastics. The Institute has many unusual research facilities. These include a completely equipped laboratory for work with radioactive materials, an Instron tester, X-ray diffraction equipment, a large spectograph, recording spectrophotometers, a pulse-propagation meter, and a completely equipped laboratory for microscopic work including phase microscopy and electron microscopy.

It is probably the only research organization in the world having at its disposal fully equipped laboratories to manufacture and finish nearly all types of fibers by all the common manufacturing systems as well as similar equipment for paper, leather, and plastics processing. These splendidly equipped laboratories serve as pilot plants for the evaluation of industrial and manufacturing problems submitted to the Foundation.

The Foundation organization is built around the three basic divisions of research, development, and testing, and is currently active in all three fields for both governmental agencies and industrial organizations. The Foundation also is of benefit to the educational program of the Institute by enabling both graduate students and faculty members to engage in research projects with a mutual instructional value.

For further information and descriptive literature about the Research Foundation, write to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts.

GENERAL INFORMATION

History

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile manufacturing subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curricula was rapid, and in 1913 it was granted the right to give regular four-year degrees in textile engineering and textile chemistry.

In 1928 the name was changed to the Lowell Textile Institute to indicate more fully its collegiate status. Its continued growth resulted in further diversification of its areas of specialization and within the past decade, degree programs have been added in the fields of leather engineering, paper engineering, electronic engineering, plastics engineering, general engineering, chemistry, engineering physics, and nuclear science and engineering.

In view of the present greatly expanded scope of its engineering program, its name was once more changed in 1953 to the Lowell Technological Institute. The Institute grants Bachelor of Science, Master of Science, and Doctor of Philosophy degrees.

Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor.

Accreditation

The Institute is a full member in the Senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. The Engineers' Council for Professional Development extends full accreditation to the curricula in textile engineering.

Graduates of this Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige in its early field of specialization, textiles, has attracted students annually to L.T.I. from approximately 35 other countries.

Coeducation

The Institute accepts both men and women for entrance provided they are properly qualified graduates of an accredited secondary school. While the great majority of its students are men, the Institute has attracted for some years a small but significant group of young women who recognize the increasing opportunities open to technically trained women in industry.

Location

Lowell Technological Institute is located 25 miles north of Boston in Lowell, Mass., a city of 100,000, long famous as a textile center and more recently as a city of increasingly diversified industries. The campus is composed of ten main buildings located on a 15-acre site along the west bank of the Merrimack River and overlooking the rapids of Pawtucket Falls. The campus site was donated by Frederick Fanning Ayer, Esquire, and the Proprietors of the Locks and Canals on the Merrimack River. Another classroom and laboratory building is currently under construction.

Buildings

Southwick Hall. This was the first building erected on the present campus and was dedicated in 1903 as the gift of the Commonwealth of Massachusetts and Frederick Fanning Ayer. It is a memorial to Royal Southwick, an ancestor of Mr. Ayer and a leading textile manufacturer and public figure of his day. It contains the gymnasium, student mail room, administrative offices of the Engineering Division and the AFROTC detachment, and the national headquarters of the American Association of Textile Chemists and Colorists.

Kitson Hall. Completed in 1903, Kitson Hall was erected by Charlotte P. Kitson and Emma K. Stott as a memorial to their father, Richard Kitson, founder of the Kitson Machine Company of Lowell. It contains classrooms and laboratories.

Falmouth Street Building. Erected in 1903 as a one-story building, it was enlarged to its present capacity for classroom and laboratory facilities in 1907 by the Commonwealth of Massachusetts.

Louis Pasteur Hall. Originally constructed as a one-story building, it was enlarged to four stories in 1937 by the Commonwealth of Massachusetts and houses laboratories and classrooms as well as the national research laboratories of the American Association of Textile Chemists and Colorists.

Olney Hall. Completed in 1952 by the Commonwealth of Massachusetts, this modern building houses complete leather and paper manufacturing facilities, advanced textile testing and electronic laboratories, and many modern lecture rooms.

Alumni Memorial Library. Erected in 1951 by the Alumni Association through contributions from alumni and friends of the Institute, the modern library is dedicated to the men and women of the Institute who served this nation in World Wars I and II and the Korean conflict.

Besides a book stack capacity of 80,000 volumes, it contains student activity offices, alumni offices, reading rooms, typing facilities, a microfilm room, and faculty studies. It houses one of the most

complete collections of textile books in the world and numerous special collections in the fields of paper, leather, chemistry, electronics, and plastics. It also serves as a depository for U. S. Government publications and is available to industrial concerns through its Industrial Corporate Membership program.

Cumnock Hall. Completed in 1954, this auditorium-administration building provides a 1000-seat auditorium for academic convocations and social activities. It also contains the offices of the President and Assistant to the President, the Dean of Faculty and the Dean of Students, Graduate School, Admissions, Special Services, Placement, the Bursar, the Registrar, and the L.T.I. Research Foundation.

Smith Hall. Erected in 1948 by the L.T.I. Building Association, Smith Hall has living accommodations for 112 students. The basement contains the college cafeteria and a medical dispensary. It was dedicated in honor of James T. Smith, pioneer educator in the textile field and the individual primarily responsible for the organization of the Lowell Textile School in 1895.

Eames Hall. The second men's residence hall was completed in 1949 by the L.T.I. Building Association and contains living quarters for 112 students, a student lounge and recreation center, and a snack bar. It was dedicated in honor of Charles H. Eames, President of the Institute from 1905 to 1945.

Equipment

The total value of the scientific and industrial equipment used in the instructional and research programs of the Institute is approximately \$12,500,000. This equipment ranges from the most delicate scientific instruments, such as the electron microscope, to full-sized industrial machines.

Textile manufacturing equipment can process all fibers, natural and man-made, by all common systems from raw stock to finished fabrics.

The textile testing laboratories are among the most completely equipped in the world and have the use of the extensive optical and electronics facilities used in advanced research work.

In the completely equipped paper and leather laboratories both leather and paper of nearly all grades and types can be fully processed from raw materials, finished, and tested by the most modern methods.

The wide variety of electronic and plastics equipment already available is in the process of being greatly augmented and consolidated in the newly expanded electronics and plastics laboratories.

Complete mechanical, electrical and chemical laboratories of the usual types round out the unusual variety of equipment available for instruction and research.

ADMISSION OF UNDERGRADUATES

New students at the Lowell Technological Institute are selected from those applicants who, during their preparatory education, have shown promise in scholastic ability and strength of character. In addition to scholastic rating and test results, a high value is placed on evidence of leadership and contributions to school and community life.

Application Procedure

Formal application for admission should be made as early as possible after the first marking period in the candidate's senior year of secondary school. Students from other countries are strongly advised to begin admission procedures not less than twelve months in advance of the expected date of enrollment.

Preliminary correspondence before the senior year is welcome and frequently helpful to the student in planning his secondary-school program to fit the needs of his freshman year at the Institute.

Requests for application blanks and all correspondence relating to matriculation at the Institute should be addressed to the Director of Admissions.

Steps to be taken for admission follow:

1. The first two pages of the admission application form should be completed by the candidate.
2. Attach a certified check or money order in payment of the application fee of \$10. (See "Student Expenses" for explanation.)
3. The whole application form should then be submitted to the office of the candidate's secondary-school principal, with the request that his office fill out pages 3 and 4 and mail the completed application directly to the Director of Admissions.

It is recommended that this procedure be accomplished as soon as possible in the candidate's senior year in secondary school so that he may be considered for admission to classes beginning the next September.

4. All candidates for admission must make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, New Jersey, with a request to take the Scholastic Aptitude Test.

Applicants for admission in the upper 20% of their high-school class may be admitted by the Chairman of the Committee on Admissions prior to the candidates' completion of the entrance examinations.

Late applicants will be given particular direction regarding entrance examinations by the Director of Admissions.

If the candidate for admission wishes to be an applicant for scholarship aid, a formal application for a scholarship must be made with the Institute.

5. Each applicant must submit to a complete health examination by his family physician. A certificate of good health, indicating the date of this examination, must then be sent in duplicate by the physician to the Director of Admissions. The Institute has prepared a special form for the convenience of the physician; two copies of this Certificate of Health will be supplied.

Each applicant must also file a Certificate of Residence that must be completed both by the applicant and by the city or town clerk of his place of residence.

6. All admission records once submitted become the property of the Institute and will not be returned.

7. Upon receipt of his letter of admission, the applicant must submit a prepayment of tuition (one-half of the first semester's tuition) within thirty days. This fee is nonrefundable.

8. A personal interview with the Director of Admissions is strongly recommended. The Office of Admissions at the Institute is open for this purpose Monday through Friday from 8:30 a.m. to 4:00 p.m. during the school year. *It is urged that appointments for interviews be made in advance.*

Requirements for Admission

The Director of Admissions, in conjunction with the Committee on Admissions, reviews all applications to determine the eligibility of each candidate for matriculation. The final decision as to the eligibility of an applicant shall be left to the discretion of the Institute.

The conditions under which an applicant may be accepted are as follows:

1. A candidate for admission must be a graduate of a secondary school approved by the New England Entrance Certificate Board, the Regents of the State of New York, or a board of equal standing.

2. (a) Because of the specialized nature of the various curricula at Lowell Technological Institute, it has been deemed advisable that all entering students shall have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	1½ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference will be given to applicants offering both chemistry and physics. In addition to the above-listed prerequisites, each applicant may offer credit in elective subjects, such as languages, other than English; history, other than American; mechanical drawing; solid geometry; advanced algebra; calculus; scientific subjects and social studies.

- (b) The combined prerequisites and electives should total at least $15\frac{1}{2}$ Carnegie units. Each such unit of preparatory credit is the equivalent of one secondary-school subject satisfactorily pursued during one academic year of at least thirty-six weeks of four forty-minute meetings each week, or the equivalent.
- (c) In evaluating the credits offered by an applicant for admission, the Institute will be guided primarily by the quality of his scholastic record and by his apparent promise on grounds of intellect and character. Therefore, an applicant whose preparation has not followed the normal pattern with respect to the accumulation of unit credits should not hesitate to apply for entrance, provided that the quality of his scholarship gives evidence of ability to do college work and provided that he is recommended by his school.

Admission with Advanced Standing

Transfer students must submit transcripts of their college record, a copy of their college catalogue and letters of honorable dismissal well in advance of their planned transfer date.

Transfer credit will be given for courses satisfactorily completed with a grade of C or better that are the equivalent in quality and scope of those given at the Institute. Final decision on transfer credit rests with the Divisional Chairman and the Dean of Students.

Additional advanced credit will not be given a student, once he has matriculated, for courses completed prior to his admission.

Special Students

Qualified applicants may be accepted for specialized work not leading to a degree. The plan of study should have a clearly defined objective and should not deviate markedly from the regularly formulated subject matter and laboratory courses at the Institute. Admission as a special student is contingent upon approval by the Director of Admissions and the Divisional Chairmen concerned in the proposed program.

Students from Other Countries

Each year Lowell Technological Institute accepts for admission foreign applicants up to 5% of the total number of students in any

given class (freshman, sophomore, etc.). There are no special procedures to be observed by foreign candidates, although it is urged that they endeavor to have the transcript of their secondary-school and/or college records, as well as all other admission materials, submitted, in English, *not less than twelve months in advance of the expected date of enrollment*. All applicants should have a considerable facility in speaking and writing English, and have financial resources sufficient at least for their first year of study. Foreign students will be expected to complete the same schedule of courses as is assigned to all other students.

In all respects, the admission procedures for foreign students are identical with those required of U. S. citizens.

To facilitate their adjustment to the life of the campus, all male students from other countries are required to live in the residence halls of the Institute and are assigned room space shared jointly with American students. Students attending for the first time should note that towels, sheets, pillowcases, and blankets must be supplied by occupants of rooms or by a laundry service that is provided to all resident students on a voluntary basis. Students are also reminded that bedding, as well as clothing, should be suitable for a climate in which temperatures normally fall well below the freezing point during the winter months.

STUDENT HOUSING AND SERVICES

Residence Halls

All male students are required to live in the residence halls unless excused in writing by the Dean of Students. These excuses are subject to review at the beginning of each semester and may be cancelled should conditions warrant.

Application for permission to occupy other living quarters may be made on special blanks available at the Dean of Students' Office. An application must be filed annually by each student. Deadlines for filing applications are: (a) for all new students (incoming freshmen, transfer students, special students, or graduate students)—on or before September 1 of each year; (b) for all regularly enrolled students—on or before June 1 of each year.

In granting special permission to live outside the residence halls, the Dean of Students will give full consideration to the following:

- a. Distance from Institute to place of legal residence.
- b. Financial hardships involved in living in residence hall.
- c. Year of the student (freshman, sophomore, junior, senior, graduate).
- d. Membership in fraternities that maintain a fraternity house.

Rooms are furnished by the Institute but are cared for by the students occupying them. Sheets, pillowcases, blankets, towels, and other personal linens must be supplied by each student, or he may subscribe to the laundry service that is provided to all resident students on a voluntary basis. Each occupant is held responsible for any damage done to furniture and equipment.

Assignments of rooms in the residence halls are made through the Office of the Dean of Students for the full academic year. Change of room is not permitted except under unusual circumstances and may be accomplished only after a formal application has been approved by the Dean of Students.

The uniform rental charge is \$275 per academic year for each student. While this charge covers occupancy during periods that the Institute is regularly in session, it may, at the option of the Institute, be extended to vacation periods.

Assignments of rooms are made as equitably as possible and in the order that applications are received. For those students who are unable to be placed in residence halls, the Dean's Office supplies a list of approved rooming houses where students may reside.

All students are cautioned to make no legal agreements or sign residence leases with persons outside the Institute. Outside residence permits are reviewed each semester and may be cancelled should conditions warrant.

Dining Hall

Dining facilities are provided on the campus in a cafeteria located on the ground floor of Smith Hall and in a snack bar located in the Students' Lounge in Eames Hall. These facilities provide additional opportunities for the students to become better acquainted as well as assure wholesome food and a balanced diet.

Guidance

The guidance program begins with the admission procedures, continues throughout the undergraduate years, and culminates in the work of the Placement Office as outlined on page 52.

Guidance in the freshman year stems mainly from the results of the diagnostic testing program, Freshman Week activities, and conferences with the faculty throughout the freshman year. During the sophomore, junior and senior years the heads of departments and the Dean of Students take over the primary responsibility for the students' personal and scholastic guidance.

The Office of the Dean of Students is open to all undergraduates from 9 a.m. to 5 p.m. daily to assist the student in attaining his academic objective, and to assure his active, enjoyable participation in the work and affairs of the Institute.

Health Service

The dispensary, in Smith Hall, is in charge of a registered nurse eight hours each school day. She is on call twenty-four hours daily, including week ends. Students receive first-aid treatment at the dispensary and are advised as to the best procedure in case of illness.

Medical services are available to the Institute twenty-four hours daily. If any student requires hospitalization, the college physician will arrange for admission to one of the three excellent, modern hospitals located in the immediate vicinity of the Institute. Medical fees and hospital charges are at the expense of the student.

Accident insurance during the academic year is compulsory and is included in the Activity and Insurance Fee. Sickness insurance is also available on a voluntary basis through the Office of the Dean of Students.

STUDENT REGULATIONS

Conduct

Students admitted to Lowell Technological Institute are assumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Such living involves full respect for the rights of others, a regard for self-discipline and good order, and a high standard of honesty and of moral conduct.

In consequence of these assumptions, the regulations are framed not to restrict the conduct of individuals or groups of students. They simply set forth the basic policies established by the Faculty in order that a large student body may live and work harmoniously together with a minimum of friction and misunderstanding. By the same token, even though the rules are neither detailed nor comprehensive, a student may be dropped from the rolls or subjected to other disciplinary action for conduct which is illegal, immoral, or inimical to the best interests of the Institute. This holds whether or not the particular offense is listed in these rules and regulations.

Attendance

Attendance is expected of all students at all classes. The supervision of student attendance is lodged in the Office of the Dean of Students, both as to the announcement of detailed instructions and the enforcement of the rules established by the Faculty. Students charged with unexcused absences, particularly absences immediately before and after holiday and vacation periods, are subject to disciplinary action.

Disciplinary Action

Disciplinary action originates in the Office of the Dean of Students. Such action may be in the form of any of the following degrees of severity: Censure, Restriction, Suspension, or Dismissal. Whenever disciplinary action is taken, a notation of such action becomes a part of the permanent record of the student.

Academic Grades

The students' grades are reported by letter as follows:

A	90-100	F	Below 60, Failure
B	80-89	I	Incomplete
C	70-79	W	Withdrawn
D	60-69	X	Dropped

The student's semester rating is a weighted value used to denote his relative standing. Values assigned are as follows: A = 4 points, B = 3 points, C = 2 points, D = 1 point and F = 0 points. These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than one semester will be obtained in the same manner as the computation for the rating of a single semester.

Scholastic Reports

Reports of scholastic standing are compiled regularly at the end of each semester and formal notification of each student's status is made at that time.

Dean's List

The Dean's List is composed of those students who have a semester rating of 3.00 or higher, with no current failures.

Probation

A student is placed on probation when his semester rating is below 1.30.* The probationary period covers the entire semester following the issuance of the semester rating which placed the student on probation.

A student on probation may not represent the Institute in any public function and may not hold class or other offices during his term of probation.

A student with a rating of less than 1.30* for two consecutive semesters shall be dropped from the Institute for at least one semester.

If a student receives a semester rating below 0.70* he shall be automatically dropped from the Institute without benefit of a probationary period.

REQUIREMENTS FOR GRADUATION

Only those students who have satisfied the following minimum requirements will be recommended for the baccalaureate:

(1) Complete successfully one of the prescribed curricula with no substitutions for major subjects therein and no unremoved failures in a major subject.

(2) Earn a cumulative rating of 1.7 or better for the entire period at the Institute.

(3) Pass 80% of the credit hours offered towards the degree with grades higher than D.

* Commencing with the Class of 1962.

Graduation Honors

Academic honors are awarded at the annual Commencement Exercises by appropriate notation on the diplomas for the baccalaureate degree, and by printing in the Commencement program the names of students who have earned such recognition. Honors are awarded according to the following standards of achievement:

- a. Any student who graduates with a rating of 3.00 for the entire period of study at the Institute shall be awarded the baccalaureate degree "*With Honors.*"
- b. Any student who graduates with a rating of 3.30 or better for the entire period of study at the Institute shall be awarded the baccalaureate degree "*With High Honors.*"
- c. The highest ranking student in each graduating class who graduates with a rating of 3.7 or better, and who has completed at least six semesters of work at the Institute, shall be awarded the baccalaureate degree "*With Highest Honors.*"

STUDENT AWARDS

The following awards are made annually by the Scholarship and Awards Committee:

- (1) *American Association of Textile Chemists and Colorists Book Prize*

Awarded to the outstanding graduating senior in the course of Textile Chemistry. The recipient is recommended by the Chemistry Division and the academic standing of the candidate is an important factor. The award includes a junior membership for one year in the A.A.T.C.C.

- (2) *American Association for Textile Technology Award*

Given annually to the member of the senior class majoring in textiles who is rated highest on the basis of scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

- (3) *Chemistry Department Award*

A book prize is awarded to the member of the freshman class who shows the highest achievement in Freshman Chemistry during the first semester.

- (4) *National Association of Cotton Manufacturers Award*

Given to the member of the graduating class in Textile Engineering (General Manufacturing Option) or Textile Technology who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

- (5) *Louis A. Olney Book Prizes*

Selected reference books are awarded annually to the outstanding freshman, sophomore, and junior students in the course of

Textile Chemistry. The recipients are recommended by the Chemistry Division chiefly on the basis of academic standing in chemical subjects.

(6) *Phi Psi Award*

Given annually to an outstanding member of the graduating class on the basis of scholastic standing, leadership, initiative, personality, loyalty, and courtesy.

(7) *President's Medal*

This award is made at Commencement to the student graduating with the most distinguished academic record in his class and "*With Highest Honors.*"

(8) *Textile Veterans Association Honor Award*

This Association, representing all the veterans of World War II now affiliated with the textile and allied industries, has established an annual honor award, in the form of a suitably engraved bronze medallion. It is given to an outstanding graduating senior in a textile course on the basis of scholastic standing, extracurricular activities, and over-all contribution to the Institute. (Preference is given to veterans.)

(9) *The Dean's Key*

This award, sponsored by the Student Council, is made annually to the member of the senior class who, in the eyes of a committee selected by the Dean of Students and composed of faculty and administrative personnel, has made the greatest extra-curricular contribution to the Institute during his four years of college.

(10) *Samuel P. Kaplan Memorial Fund Awards*

The New England Knitted Outerwear Manufacturers' Association has set up a fund in memory of Samuel P. Kaplan to enable two prizes to be awarded each year to outstanding students in the basic knitting course. An award of \$100 will be granted to the highest-ranking student at the end of the first semester and a similar award will be made at the end of the second semester.

(11) *Barnett D. Gordon Award*

The Barnett D. Gordon Award of \$250 is to be presented to the young man or young woman who achieves the highest rank in the mathematical section of the Scholastic Aptitude Tests which are required of all entering freshmen applying for admission to L.T.I.

(12) *The Circle K Book Award*

This award consists of a book which is awarded annually to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

(13) *Helen U. Kiely Award*

This award, made at Commencement, acknowledges by permanent inscription on a plaque the senior student in Paper Engi-

neering selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

STUDENT EXPENSES*

The various student expenses described in this section apply only to the regular day school of Lowell Technological Institute. The fees and expenses of the Evening Division are described in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without advance notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in the payment of fees may be authorized, but all fees must be paid on or before the close of the sixth week of classes of the semester involved. Requests for delay must be approved before a student's registration is complete.

APPLICATION DEPOSIT \$10

Payable by certified check or money order and filed with the Director of Admissions at the time of application.

- a. If the applicant is accepted for admission and is duly enrolled as a student at the Institute, the entire amount of this deposit shall be credited toward his tuition charges on the day of registration.
- b. If the applicant is not accepted for admission as a student, the entire amount of this deposit shall be refunded.
- c. If the applicant is accepted for admission but does not choose to enroll as a student, no refund shall be made.
- d. If the applicant is accepted for admission but is called to duty in the Armed Services of the United States, he shall, upon presentation of suitable evidence of this fact, be entitled to a refund of the entire amount of the application deposit.
- e. The Institute requires the prepayment of 50% of the first semester's tuition within 30 days after the applicant has been accepted for admission. For Massachusetts residents this amounts to \$50. This prepayment will be forfeited if the student fails to register at the Institute. In rare cases,

* The matter of student expenses is currently under consideration by the Board of Trustees and is subject to revision.

such as sickness which would prevent the applicant from coming, this rule may be waived at the discretion of the Dean of Students.

TUITION	(per year)
U. S. citizens who are residents of Massachusetts	\$200
U. S. citizens who are residents of states other than Mass.	\$300
All others	\$550

Special students pay, in general, the full tuition fee. However, if enrolled in only a limited number of courses, a special student may make application to the President for a reduction in tuition.

Because Lowell Technological Institute is a state-supported institution, its educational program and facilities are made available at a low tuition rate to students entering from the Commonwealth. Eligibility for admission as a student entitled to the low residential tuition is determined under policies established by the Board of Trustees.

- a. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community claimed as legal residence, stating that the student's parents or guardian is a legal resident of the Commonwealth of Massachusetts.
- b. The residence of a minor shall follow that of the parents, unless the minor has been emancipated. A minor student who has been emancipated shall, in addition to the requirements respecting residence, present satisfactory documentary evidence of emancipation.
- c. A minor under guardianship shall be required to present satisfactory documentary evidence of the appointment of a guardian in addition to the certificate of residence of the guardian.
- d. The residence of any applicant for admission, as shown on the application for admission at the time of initial application, shall determine the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment as an undergraduate, graduate, and/or special student.
- e. The residence of a wife shall follow that of the husband.
- f. The prescribed form of application for classification as to residence shall be executed by each student. Misrepresentation of facts to evade payment of the proper rate of tuition shall constitute sufficient cause for suspension or permanent separation from the Institute.

- g. Payment of one-half of the total yearly tuition will be made during the registration for each semester.
- h. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

Note: Wherever mentioned above, the word *residence* is considered to mean *legal domicile*.

ROTC DEPOSIT \$25

This deposit covers loss of, or damage to, uniform or equipment used for ROTC instruction. It is required of all students enrolled in ROTC. The entire amount, less charges, will be refunded upon the completion of the ROTC requirements. If, at any time, the charges against a student exceed the amount on deposit, the student will be required to pay such charges and to make an additional deposit of \$25.

ACTIVITY AND INSURANCE \$40

Each student will pay \$40 the first semester for the entire academic year as a student activity and insurance fee. The payment of this fee entitles the student to free admission to all athletic events, a mailbox in the campus post office, a subscription to the student newspaper, and a copy of the yearbook. A portion of this fee helps to support the general student activities under the jurisdiction of the Student Council. It pays for the compulsory accident insurance policy which covers each student against accidents during the academic year and also contains a compulsory bonding fee which protects the Institute against unpaid student charges.

RESIDENCE HALLS \$275

All students, except those who live in Lowell or the surrounding community, may be required to live in one of the residence halls (see page 25 for details). The double rooms rent for \$275 per student per year. One-half of the rent (\$137.50) is payable at the start of each semester.

LABORATORY AND MATERIALS FEE

To cover the cost of materials and normal breakage in all laboratories, each student will be charged as follows:

All freshmen \$12/semester

Upperclassmen enrolled in:

- (a) Textile Technology, Textile Engineering, General Engineering, Engineering Physics, Nuclear Science and Engineering, or Electronic Engineering . . . \$12/semester

- (b) Paper, Leather, or Plastics Engineering \$17/semester
- (c) Textile Chemistry and Chemistry . \$22/semester

The above charges are not refundable. Excess breakage will be billed direct to the student. These fees are payable each semester regardless of the number of laboratories taken and represent an average flat charge per semester for the regular four-year program in each of the above courses.

The above fee must be paid before a student can be admitted to laboratory work.

COMMENCEMENT FEE (Seniors only) \$15

This covers Commencement expenses such as degree and case, rental of cap and gown, invitations, printing, and such other expenses as shall be approved or directed by the President.

LATE REGISTRATION FEE \$5

Any student who does not complete his registration (including the payment of all fees) by the close of the registration period may be required to pay an additional fee of \$5.

OFFICIAL TRANSCRIPT FEE \$1/copy

Each student will be allowed free of charge a total of three transcripts of his scholastic record. A charge of \$1 per copy will be made for each *additional* transcript.

AUDITING FEE \$5/credit hour

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge provided proper approval is obtained.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay \$5 per credit hour to audit a course and must obtain proper approval.

BOOKS AND MATERIALS—Students must provide their own books, stationery, tools, etc., and pay for any breakage or damage that they cause to machines, laboratory equipment, and other property of Lowell Technological Institute.

All raw stock and yarn furnished to the students, and all the productions of the Institute, remain or become its property, except by special arrangement, but each student is allowed to retain specimens of yarn or fabrics that he has produced, if mounted and tabulated in accordance with the requirements of the department. It is understood that the departments may retain such specimens of students' work as they may determine.

No books, instruments, or other property of the Institute loaned to the students are to be removed from the premises except by special permission.

REFUND SCHEDULE—Applications for refunds, filed with the Bursar on withdrawal, will be made in accordance with the following table:

<i>No. of Weeks</i>		<i>Refund Rate</i>
<i>At least</i>	<i>But less than</i>	
0	2	80%
2	3	60%
3	4	40%
4	5	20%
5 and over	None

SUMMARY OF EXPENSES PER YEAR

TUITION

U. S. citizens who are residents of Massachusetts	\$200
U. S. citizens who are residents of states other than Mass.	\$300
All others	\$550
Dormitory rate	275
Laboratory and Materials Fee	
(a) All freshmen	24
(b) Upperclassmen enrolled in:	
Electronic Engineering, Engineering Physics, General Engineering, Nuclear Science and Engineering, Textile Engineering, or Textile Technology . . .	24
Leather, Paper, or Plastics Engineering	34
Chemistry and Textile Chemistry	44
Student Activity and Insurance Fee	40
ROTC Deposit	25
Books, supplies and related miscellaneous expenses . . .	100

STUDENT ACTIVITIES

Lowell Technological Institute believes that sound educational practice seeks to develop the whole personality of the student. Accordingly, Faculty and Administration encourage extra-curricular activities and support the development of a varied and well-rounded program of activities to supplement the purely academic phase of undergraduate life. This program provides opportunity for participation in formal and informal sports, in class and campus self-government, and in the many clubs and special interest activities which appeal to the varied interests of the student body.

Student Council

The Student Council is the chief body for the conduct of self-government in student affairs. It is composed of four officers elected at large by the student body, the president of each undergraduate class, and one representative from each of the classes.

By virtue of its function as chief governing body for student affairs, it exercises administrative control over all campus organizations formed under its supervision; represents the student body in matters requiring conference with the Administration and Faculty; investigates grievances submitted by students or student groups; sponsors all-campus dances, banquets, and other social affairs; and supervises the expenditure of the unallocated portion of the student activity fee. It functions in accordance with the specific prescriptions of its constitution and by-laws.

Athletics

The Athletic Association promotes an extensive varsity and intramural sports program. All students are members of the Athletic Association and receive free admission to all intercollegiate contests played at home.

Soccer, basketball and baseball are varsity sports at the Institute. Competition is chiefly with teams in the northeast portion of the country. Golf and tennis teams also compete regularly with other colleges in the area.

Intramural sports are sponsored by the Director of Intramural Athletics with an interesting year-long program of both league and informal competition between the classes, residence halls, and fraternities.

Band

The AFROTC Band is composed primarily of cadets who are musicians or who desire to learn to play a band instrument. In addition to providing the music for the AFROTC ceremonies, the

band adds considerably to the color and life of the campus by participating in various Institute and civic programs.

Circle K

The Circle K Club is the student chapter of the Kiwanis at the Institute. In addition to performing many services in the public interest, it assists the administration of the Institute in the freshman orientation program each year.

Duplicate Bridge Club

The Duplicate Bridge Club is open to all students and faculty members at the Institute. The club has approximately ten playing sessions per year to determine the championship team. Student members also participate in the annual national Intercollegiate Duplicate Bridge Tournament.

Fraternities

The Interfraternity Council fosters the common interests of the four fraternity chapters at the Institute. This organization sponsors joint social and athletic contests among the fraternities.

The four fraternities have their own houses for fraternity socials and meetings, providing centers for the social life off the campus. The fraternities are: Delta Kappa Phi, Omicron Pi, Phi Psi, and Pi Lambda Phi.

General Vandenberg Air Society

The purpose of the General Vandenberg Air Society is to unite selected advanced AFROTC cadets by a fraternal bond in order to further the mission and traditions of the Air Force. The Society is affiliated with the Air Force Association which further extends the fraternal bond to include air-minded individuals. A squadron of the General Vandenberg Air Society has been established at this Institute and is a chapter of the National Society. The Society is responsible for a cadet sports program and a variety of social affairs during the academic year. The Military Week End, the Society's social highlight, features a colorful drill ceremony and has as its climax the formal Military Ball at which announcement of the cadet officers is made.

International Students Circle

This club lists all foreign students at the Institute as its members. It serves to bring into close contact all these students who may have some difficulty in becoming adjusted to a new language or way of living. These students are in demand by local civic groups to serve as speakers on many programs.

The Nucleus

The club was initiated to serve as a focal point for students to meet and present ideas and reports regarding actual activities in industry. The club has a membership limit of fifteen members who are the leaders of all the major activities on the campus. A high scholastic rating is also a prime requisite for active participation.

“Pickout”

The “Pickout” is the annual yearbook of the campus. Those who serve on the staff secure a valuable training in the editorial, art, and business problems involved in the production of a top-quality photo-literary history of the academic year.

Professional Societies

The following societies conduct monthly meetings at which students and outstanding speakers present technical papers and lectures. Frequent field trips to industrial plants are also made by the members. These societies include:

- (1) American Association of Textile Chemists and Colorists, Student Chapter
- (2) American Society of Tool Engineers, Student Chapter
- (3) American Society of Mechanical Engineers, Student Chapter
- (4) General Engineering Society
- (5) Institute of Radio Engineers, Student Chapter
- (6) Leather Engineering Society
- (7) Paper Engineering Society
- (8) Plastics Engineering Society
- (9) Textile Society
- (10) Physics and Mathematics Society

Radio Station

The Radio Station (WLTI) is an all-student enterprise built and maintained by members of the Lowell Technological Institute Broadcasting Society. Programs are transmitted by a carrier current to the buildings of the campus from the station studio.

The radio station sells air time to local merchants and thus is a self-supporting organization. It provides a fine opportunity for students to learn business practices as well as broadcasting and radio techniques.

Religious Groups

Hillel. The Hillel Counsellorship was established to provide social, cultural and religious programs for the Jewish students at the Institute. Discussion groups are held weekly and brunches or

dances monthly. Speakers are invited to talk on subjects of interest to the whole student body. Hillel groups, located at most of the larger colleges and universities, are sponsored by the national B'nai B'rith organization.

Iona Student Fellowship. A group composed of students and faculty members of various races and creeds who, by uniting in a common fellowship, attempt to understand the will of God through worship, study and action, and thus realize it both in personal living and in working toward a better society.

Newman Club. The Newman Club is an organization sponsored by the Catholic students at the Institute. It conducts programs of a social and religious nature.

Rifle Team

The AFROTC Rifle Team is open to all AFROTC cadets. Competent staff members train the group, with the aid of National Rifle Association members, for intercollegiate competition matches. The major match of the year is the William Randolph Hearst Trophy Match.

Scholastic Honor Society

Membership in Tau Epsilon Sigma is open to members of the junior and senior classes who are elected on the basis of outstanding scholastic achievement and character.

Sorority

The sorority, Phi Sigma Rho, provides a center for the social life and association of the young women enrolled in the various programs of the Institute.

T.O.C.

The Tech Orientation Committee has as its special function the introduction of the new student to college life. During Orientation Week, the first week of school for the freshmen, a series of activities is planned by T.O.C. to enable freshman class members to meet each other and to realize their responsibilities to their college.

Tech Players

All the theatrical activities of the Institute are centered around the Tech Players. For years the annual production of this group has been a high point in the social calendar.

"The Text"

"The Text" is the campus newspaper. Prepared and edited by the students, this bi-weekly publication offers excellent journalistic and business experience to those who work on its staff.

Varsity Club

This club is composed of students who have earned letters in any of the intercollegiate sports, baseball, basketball, golf, soccer, and tennis. Its purpose is to help athletes academically and to foster a lasting friendship among the men participating in athletics.

FINANCIAL AID TO STUDENTS

SCHOLARSHIPS

A large number of scholarships are available to students and prospective students at Lowell Technological Institute through funds contributed by various trusts, organizations, civic bodies and industrial firms. Many of the scholarships are renewable yearly for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are only for a specified period of time.

All entering freshmen who are candidates for scholarships should make direct application to the Director of Admissions, Lowell Technological Institute, Lowell, Massachusetts, before April 1, and should have completed the Scholastic Aptitude test of the College Entrance Examination Board by that date. To arrange for this test, candidates must also make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, New Jersey, with a request to take the Scholastic Aptitude test.

Unless otherwise specified, all scholarships will be granted by vote of the Scholarship and Awards Committee of the Institute. Any student holding a scholarship must remain in good standing in college and progress normally from year to year. While honor grades are not required, scholarship holders are expected to do scholarship-level college work. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

Available for Freshmen and Upperclassmen

1. ALBANY FELT COMPANY SCHOLARSHIP

One annual grant to Lowell Technological Institute in the amount of \$500 to an entering freshman is made by the Albany Felt Company. Recipients of these scholarships will be offered the opportunity for summer employment at the Albany Felt Company while in college.

2. ALUMNI ASSOCIATION SCHOLARSHIPS—LOWELL TECHNOLOGICAL INSTITUTE

Scholarship funds under the care of the Alumni Association make available several scholarships a year which cover tuition and miscellaneous fees. These scholarships are renewable if a satisfactory scholastic standing is maintained.

3. BERKSHIRE HATHAWAY, INC. SCHOLARSHIPS

A number of scholarships covering tuition and living expenses for four years are offered in textile engineering and technology

by Berkshire Hathaway, Inc., Providence, Rhode Island. Eligible applicants are:

a. Male employees of Berkshire Hathaway, Inc. who have had adequate secondary-school training.

b. High-school graduates who are sons of present employees.

Interested students should contact Berkshire Hathaway, Inc., 704 Hospital Trust Building, Providence 1, Rhode Island.

4. **RUSSELL L. BROWN SCHOLARSHIP**—donated by Davis and Furber Machine Company

This scholarship is open to a student acceptable to Lowell Technological Institute who plans to enroll in the curriculum of textile engineering or textile technology. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. The selection is based on general scholarship, initiative, and need. The stipend is \$300. The appointments are for one year only but are renewable.

5. **FOSTER GRANT SCHOLARSHIP**

A \$500 scholarship to defray tuition costs of an outstanding sophomore from Massachusetts in the Plastics Engineering course has been established by Foster Grant Co., Inc. of Leominster.

6. **JOSEPH KAPLAN SCHOLARSHIPS**

Two \$250 scholarships have been established by a fund set up by Joseph Kaplan to be awarded annually to the winners of Technorama, a science fair for Merrimack Valley high schools held each year at the Institute.

7. **A. C. LAWRENCE LEATHER COMPANY SCHOLARSHIP**

The A. C. Lawrence Leather Company in Peabody, Massachusetts, makes available a \$500 scholarship on a one-year basis to a student in leather engineering at Lowell Technological Institute. Preference is given to an employee or member of an employee's family, or to a resident in a town in which the Company operates. If no eligible applicants are available, the award will be open to any member of the Leather Engineering Department on the basis of merit.

8. **LEATHER ENGINEERING DEPARTMENT SCHOLARSHIPS**

The Leather Engineering Department has funds for several scholarships and awards under its jurisdiction which it periodically releases for scholastic aid purposes through the Institute Scholarship Committee. These funds have been made available by interested industrial firms and trade organizations. These scholarships are available to deserving students enrolled in the Leather Engineering course who need financial assistance for scholastic purposes.

9. CITY OF LOWELL SCHOLARSHIPS

The City of Lowell has appropriated funds to provide a total of five scholarships every two-year period. These scholarships are awarded on the basis of competitive examinations to residents of the City of Lowell, Massachusetts, who are enrolled in the freshman class at the Institute. The amount of the scholarship is \$200, which is full tuition at the Institute, and it is renewable provided satisfactory scholastic grades are maintained.

10. COMMONWEALTH OF MASSACHUSETTS SCHOLARSHIPS

Ten scholarships of \$250 each year are available for young men and women who are residents of the Commonwealth of Massachusetts and are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examinations and the scholarships are renewable provided satisfactory grades are maintained.

11. THE McLaurin-Jones Scholarship

This scholarship is awarded annually to a member of the Framingham, Needham, Tantasqua Regional, and Ware, Mass., Netcong, N. J., or Homer, La., high school graduating class, or to an employee or son of an employee of the Ludlow Papers Company (formerly the McLaurin-Jones Company) for work in the Paper Engineering Department. The scholarship for \$500 is renewable from year to year for four years if a satisfactory scholastic record is maintained.

12. MOHAWK CARPET MILLS TEXTILE SCHOLARSHIP

A \$2,000 scholarship has been made available to high-school graduates or employees of the Mohawk Carpet Mills who are residents of New York State. All applicants must have applied for enrollment in one of the various textile courses at the Institute in order to be eligible. Application must be made to the Mohawk Carpet Mills, Inc., Amsterdam, New York.

13. NEW ENGLAND TANNERS CLUB SCHOLARSHIP

This scholarship is awarded by annual vote of the New England Tanners Club and is granted to a student in Leather Engineering at Lowell Technological Institute. Preference is given to employees of the member companies of the New England Tanners Club or to their families. If no eligible applicants are available, awards will be open to others on the basis of secondary-school scholastic performance and evidence of potential leadership. The amount of the scholarship is \$1,000, awarded on a one-year basis.

14. SALEM OIL & GREASE COMPANY SCHOLARSHIPS

Normally, two scholarships of \$500 each are available each year through the Salem Oil & Grease Company in Salem, Massachu-

setts, which established the awards as a memorial to the late Harold T. N. Smith, a founder of the company. These are allocated to candidates enrolled in the Department of Leather Engineering depending on scholastic ability and financial need.

15. SHAPIRO FUND, INC. AWARDS

Two \$500 scholarships are given each year through the Shapiro Scholarship Fund, Inc. of New York City. The criteria governing these scholarships are financial need and scholastic ability.

16. SYLVAN I. STROOCK SCHOLARSHIP—S. STROOCK & CO., INC.

Awards are made on the basis of scholarship, financial need, leadership, and promise of success in textile fields. The sum available for scholarship purposes is \$500 per year, offered annually at the discretion of the Scholarship Committee.

17. H. WEBSTER THOMAS MEMORIAL SCHOLARSHIP—donated by the Rohm and Haas Corporation of Philadelphia, Pennsylvania

This scholarship is awarded for a four-year period to a student in Leather Engineering at Lowell Technological Institute. The amount of the scholarship is \$500 per year.

18. UNITED ELASTIC CORPORATION SCHOLARSHIPS

Scholarships in the amount of \$250 are available to students taking one of the various textile courses through the United Elastic Corporation, Easthampton, Massachusetts.

These scholarships have been established primarily for employees of the United Elastic Corporation, or members of their families. Other residents of the communities where plants are located, however, may enter applications for consideration. Preference is given to native New Englanders and to those who agree to work summers in approved mills.

Qualifications for scholarships include good character and standing in the community, aptitude for technical training, and ability to pass entrance requirements of Lowell Technological Institute. With the approval of the United Elastic Corporation and the Lowell Technological Institute, scholarships may be awarded to deserving upperclassmen.

Each scholarship is for a one-year period and further extension if the performance of the student during the year is satisfactory. The United Elastic Corporation will, so far as possible, furnish suitable employment to the student during the summer vacation period and following graduation.

All applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, Lowell, and Littleton, Massachusetts; West Haven, Connecticut; and Stuart, Virginia.

19. JACOB ZISKIND MEMORIAL FUND FOR FRESHMEN

This scholarship was established by the employees of the Merrimack Manufacturing Company in memory of Jacob Ziskind, and is applicable to freshmen only.

Qualifications for the scholarship include good character, scholastic record, initiative and ability to pass the entrance requirements at Lowell Technological Institute.

Available for Upperclassmen Only

1. ALLIED CHEMICAL CORPORATION SCHOLARSHIP

This scholarship is to be awarded by the Scholarship and Awards Committee to a worthy upperclassman majoring in Textile Chemistry or Textile Engineering. This scholarship grant is for \$500 plus tuition and is given by the Allied Chemical Corporation.

2. AMERICAN TEXTILE MACHINERY ASSOCIATION SCHOLARSHIP

The Institute Board of Trustees has established an American Textile Machinery Association scholarship of \$150, to be awarded to a qualified student majoring in textiles.

3. ARTHUR BESSE MEMORIAL SCHOLARSHIP

The scholarship is awarded by the Arthur Besse Memorial Trust to a student majoring in textiles and planning to continue in that industry after graduation. Awards are based on need, scholarship, and qualities of character and leadership. The amount of the scholarship is \$500 a year and is renewable if a satisfactory scholastic record is maintained.

4. BOSTON PAPER TRADE ASSOCIATION SCHOLARSHIPS

Two scholarships are open to any sophomores, juniors, or seniors enrolled in the Paper Engineering Department who are residents of New England. They are awarded on the basis of scholarship and general character. The amount of each scholarship is \$150. It is anticipated that the scholarships will be made renewable each year by the Association.

5. BURLINGTON INDUSTRIES FOUNDATION SCHOLARSHIP

The Burlington Industries Foundation scholarship is valued at \$1,000, payable \$500 a year for the junior and senior years of the student selected by the Institute on the basis of his leadership, scholarship and financial need.

6. CHEMSTRAND CORPORATION SCHOLARSHIP

The amount of \$500 has been made available by the Chemstrand Corporation for a superior, deserving student enrolled in the Textile Engineering course.

7. CIBA COMPANY, INC. SCHOLARSHIP

This scholarship, donated by the Ciba Company, Inc., is in the amount of \$500 each for a junior and a senior in the textile

dyeing and chemistry course at the Institute. Selection is based upon scholastic prowess.

8. OWENS-CORNING FIBERGLAS CORPORATION SCHOLARSHIPS

The Textile Products Division of the Owens-Corning Fiberglas Corporation offers two scholarships for tuition and fees valued up to \$750 annually to two students in the field of engineering. Awards are made by the Institute Scholarship Committee and are renewable, provided a satisfactory scholastic average is maintained. Recipients are guaranteed summer employment by the company and will be given strong consideration for full-time employment after graduation, but they are not obligated to accept employment with the company.

9. THE GEHRING FOUNDATION MEMORIAL SCHOLARSHIPS—in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

These scholarships are made possible as a result of the Gehring Memorial Foundation of New York. Selection of recipients made by the Scholarship Committee may be reviewed by the Gehring Foundation. The amount of the scholarship is \$75 per semester and is renewable if a satisfactory scholastic record is maintained.

10. RALPH E. HALE SCHOLARSHIP

This scholarship was established by the Northern New England Section of the American Association of Textile Chemists and Colorists in memory of Ralph E. Hale, 1951 Chairman-elect of the Section and a 1931 graduate of L.T.I. This scholarship is awarded annually to a student at the completion of the junior year in the course in textile chemistry. The amount of the scholarship is \$250 per year.

11. INTERCHEMICAL CORPORATION SCHOLARSHIPS

Four \$250 scholarships have been made available by the Interchemical Corporation of Pawtucket, R. I., to students completing two years of undergraduate work at Lowell Technological Institute. They are awarded on the basis of scholastic achievement, character, and leadership potential. Preference is given to majors in textile chemistry or allied fields.

12. NEW ENGLAND PAPER MERCHANTS ASSOCIATION SCHOLARSHIP

This scholarship is open to any sophomore, junior or senior in the Paper Engineering Department who is a resident of New England. It is awarded on the basis of scholarship and general character. The amount is \$150. It is anticipated that it will be made renewable each year by the Association.

13. DR. GEOFFREY R. BROUGHTON PAPER ENGINEERING SCHOLARSHIPS

Three prizes of \$100 each are awarded at the beginning of each fall semester to the top ranking students enrolled in each of the sophomore, junior and senior classes of paper engineering.

Three prizes of \$100 each are awarded at the beginning of each spring semester on the same basis. These prizes were made available by a number of interested companies for students enrolled in the Paper Engineering Department.

14. JACOB ZISKIND MEMORIAL SCHOLARSHIP FUND

This scholarship was established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes. Scholarships are awarded annually and are renewed provided a satisfactory scholastic record is maintained. The scholarship includes tuition, books, supplies and such other expenses as are required to enroll a student in his course. Recipients are selected by the Faculty Scholarship Committee and must have demonstrated high scholarship, financial need, and qualities of good character and leadership. Students from the sophomore, junior, and senior classes are eligible. Preference shall be given to, but not restricted to, those students who have received in their freshmen year the Jacob Ziskind Memorial Fund for Freshmen.

15. UNITED STATES RUBBER COMPANY FOUNDATION SCHOLARSHIP

This scholarship is awarded to a student displaying leadership, capacity for higher education, and need. Completion of at least two years of college is required, with some evidence of an interest in a career in industry. The recipient assumes a moral obligation to repay 25% to the scholarship fund.

16. SOCIETY OF PLASTICS ENGINEERS SCHOLARSHIP

This \$200 scholarship is given by the Eastern New England Section of the Society of Plastics Engineers, Inc. to be awarded to a deserving junior majoring in Plastics Engineering. The student is selected by the Institute Scholarship and Awards Committee.

LOAN FUND

A loan fund is available for the purpose of assisting upperclassmen to continue their education at Lowell Technological Institute. Students may make application for a loan through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments on any loan which are made while the student is still in school are interest free. Loans repaid after the student leaves school (for whatever reason) bear 4% interest beginning three months after the date on which the student officially leaves school. Repayments are not required until the student separates from Lowell Technological Institute, at which time repayments are due quarterly at a rate of \$10 per quarter the first year and \$20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time so as to reduce indebtedness at a more rapid rate.

FELLOWSHIPS

Several fellowships are available to students pursuing graduate studies.

1. Teaching Fellowships

Every year the Institute has available through the Commonwealth of Massachusetts a limited number of teaching fellowships for qualified students in the Graduate School who are working toward the Master of Science degree in Textile Chemistry or Textile Engineering. Appointees normally carry a half-time study load and are required to spend 12 to 15 hours per week in the supervision of undergraduate laboratories and review sections. Annual stipend is about \$1500 with reappointment for a second year contingent on satisfactory performance of duties. Application forms may be obtained from, and must be filed prior to April 30 with, the Director of Graduate School. Appointments are made June 1 for the next academic year.

2. Research Fellowships

A limited number of research fellowships also are available to qualified students through the Celanese Corporation of America, Linde Air Products Company, and National Aniline Division, and are principally in the Division of Chemistry for students working toward the Master of Science degree in Textile Chemistry. Research may involve fundamental or applied chemistry. Appointees are expected to devote full time to study and research. Stipends are from \$1200 to \$1500 per year. Application forms may be obtained from, and must be filed prior to April 30 with, the Director of Graduate School. Appointments are made June 1 for the next academic year.

3. Coats and Clark, Inc. Fellowship

This fellowship is available only to graduates of textile colleges. It provides for graduate work at the Massachusetts Institute of Technology and pays approximately \$700 per year plus tuition. Application should be made directly to M.I.T.

THE AIR FORCE ROTC UNIT

An Air Force Reserve Officers Training Corps unit was established at the Lowell Technological Institute on July 1, 1951. Instruction began with the opening of the first semester of the academic year 1951-52.

By vote of the Board of Trustees, all able-bodied nonveteran male students enrolling in Lowell Technological Institute for the first time on or after September 13, 1951, must satisfactorily complete the basic ROTC work (freshman and sophomore years) before receiving a Bachelor of Science degree. The President of the Institute may waive this requirement and permit the substitution of an equivalent amount of work only for those individuals who are not liable to military service under existing laws and regulations (for example, not a citizen of the United States, previous military service, etc.).

Uniforms and all equipment and textbooks required for the ROTC work will be supplied by the United States Air Force. Students in the Advanced Course will receive the standard cash payment allowed by the Air Force in lieu of subsistence.

Mission

The mission of the AFROTC unit is to develop in each cadet those attributes essential to his progressive advancement to a commission as a second lieutenant in the United States Air Force Reserve and, further, to prepare him to fill positions of increasing responsibility as a commissioned officer in such duties in the Air Force as may be required by the national defense effort.

The AFROTC program takes into consideration the fact that many of the academic subjects in which Institute students are enrolled have as much direct relationship to military duties as they have to a civilian career. The courses contained in the AFROTC curriculum have been carefully selected to augment those academic subjects. The purpose of this course of instruction, then, is to enhance the otherwise high qualifications of the student with a thorough Air Force background.

Basic Course

The work covered in the first two years is considered the Basic Course. In addition to exercises in leadership and drill, this work includes classroom instruction in the air vehicle, elements and potentials of air power, military instruments of national security, and professional opportunities in the USAF. As stated above, the satisfactory completion of the Basic Course is a requirement for the Bachelor of Science degree in all courses offered at the Institute.

Cadets who satisfactorily complete the Basic Course may apply for the Advanced Course subject to approval by the Selection Board.

Advanced Course

The Advanced Course, consisting of the last two years of Air Force ROTC instruction supplemented by a summer camp, is designed to develop in the student to the highest degree possible those understandings, attitudes, skills and attributes of leadership considered essential in the development of all Air Force commissioned officers.

Air Science III, taught during the student's junior year, analyzes such problems as command staff concepts; leadership laboratory; problem-solving techniques; communications process; principles and techniques of learning and teaching; Air Force correspondence and publications; military law and courts, and boards; applied air science, including aerial navigation, weather, and functions of the Air Force Base.

Air Science IV, taught during the student's senior year, contains a review of the previous years of air science; a critique of the summer camp training; leadership and management; military aspects of world political geography; principles of management; military aviation and the art of war; career guidance; and briefing for commissioned service.

Normally, students who successfully complete the Advanced Course are commissioned as second lieutenants in the United States Air Force Reserve and subsequently receive training as pilots or aerial observers. A limited number of students who show outstanding capability in non-flying engineering skills are also awarded commissions.

Summer Camp

In addition to completing satisfactorily the subjects required in the above generalized curriculum, each cadet enrolled in the Advanced Course is required to supplement his training by attending a summer camp of approximately four weeks duration. Usually this camp is attended during the summer preceding his senior year. Transportation from the legal residence of the cadet to the camp and return, uniforms, food, lodging, and medical and dental care are provided by the Air Force and, in addition, the cadet receives the pay of a basic airman.

Field Trips

Periodically, the Department of Air Science conducts field trips to various Air Force installations for the purpose of orientation. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in

flying to gain as much information as possible about the operational phase of the Air Force.

Veterans

A veteran who qualifies for and completes successfully the Advanced Course of AFROTC will be commissioned a second lieutenant in the Air Force Reserve. Under present Air Force regulations, there is no requirement for an active duty tour; however, a veteran AFROTC graduate may apply for active duty as an officer. The Professor of Air Science may waive, in consideration of military service, portions of the Basic Course which cannot be completed prior to entrance into the Advanced Course.

Contributions to Student Life

In addition to the military and academic phases of its program, the Department of Air Science sponsors various extracurricular activities which are designed to produce a well-rounded cadet. Much of this activity is undertaken by the General Vandenberg Air Society.

Cadet Decorations and Awards

A number of medals are awarded to selected cadets and cadet officers at a special Parade and Review held each spring.

Thomas F. Costello Trophy—Awarded to the AS IV cadet from the Greater-Lowell area displaying an outstanding degree of leadership ability.

Alumni Medal—Awarded annually to the outstanding cadet, regardless of class, for superior Air Science, academic and extracurricular achievement.

Convair Cadet Award—Awarded for over-all contribution to the nation's air strength.

Chicago Tribune Awards—Gold Medal for the outstanding cadet in the Advanced Course; Silver Medal for the outstanding cadet in the Basic Course.

Armed Forces Communications and Electronics Association Award—Awarded to the senior cadet demonstrating outstanding qualities of military leadership, high moral character, and definite aptitude for military service who has distinguished himself academically in the field of communications and electronics.

Sons of the American Revolution ROTC Award—Awarded to the basic cadet distinguishing himself in leadership, military bearing, and academic excellence.

Trustees' Medal—Awarded to the outstanding Air Science III cadet maintaining high academic average and demonstrating the

best performance in related classroom activities. This is presented by the Board of Trustees of the Institute.

Reserve Officers Association Medal—Awarded to the AS IV cadet distinguishing himself for leadership, excellence of character, initiative, force, personality, neatness, discipline, and related traits.

Air Force Association Medal—Awarded to the outstanding AS IV cadet on the basis of four-year achievement.

Distinguished Commander Medal—Awarded to the distinguished cadet commander, regardless of class, for outstanding performance of duty.

Distinguished Squadron Commander Medal—Awarded to cadet majors for outstanding performance throughout the academic year in leadership and drill.

Distinguished Flight Leader Medal—Awarded to two AS III cadets for outstanding performance in leadership and drill.

Distinguished Non-commissioned Officers Medal—Awarded to the two most distinguished non-commissioned officers for outstanding performance in leadership and drill.

Distinguished Air Science II Cadet Medal—Awarded to the two most distinguished AS II cadets.

Distinguished Air Science I Award—Awarded to the three most distinguished first-year basic cadets.

AFROTC Marksman Medal—Awarded to three cadets for contribution to the support of the AFROTC Rifle Team and successful marksmanship achievement in national competition of the National Rifle Association.

Distinguished Bandsman Award—Awarded to three cadets for outstanding performance in the AFROTC Band.

Distinguished Military Graduate Award—Awarded to outstanding AFROTC graduates based on four years of over-all academic and military achievement. A recipient of this award may apply for a regular commission as second lieutenant in the United States Air Force.

Distinguished Military Cadet Award—Presented annually to AS III cadets who have demonstrated a high quality of leadership, moral character, academic achievement, and aptitude for military service. This award is a prerequisite for the Distinguished Military Graduate Award.

Vandenberg Cup—Awarded to the squadron that has accumulated the highest number of points for various competitions and extracurricular participation during the academic year.

PLACEMENT

Industrial Training Program

The Placement Office with the assistance of industry endeavors to place every qualified underclassman during the summer vacation periods in an industrial position similar to the student's major field of interest at the Institute. These training opportunities are available in chemistry, electronics, leather, paper and textiles, and are open to all students who have completed their sophomore year except those on scholastic or disciplinary probation.

The objectives of the undergraduate Industrial Training Program are:

- (1) To help supply essential industrial experience to the undergraduate;
- (2) To provide experience in human engineering only obtained in industry;
- (3) To furnish an employment pool enabling industry to preview individual students;
- (4) To further the liaison between the Institute and industry.

Placement Service

The Placement Office maintains active contacts with a number of industrial firms throughout the country in each of the fields of engineering presented at the Institute. A complete file of opportunities and data on various industries and companies is available to the members of the graduating class in the Placement Office.

The office arranges for the visits of representatives from industrial firms to interview students. A series of industrial seminars is conducted in which industrial speakers outline opportunities in particular industries and the various positions within the companies.

In addition to assisting in the placement of graduating students, it also assists industry in the difficult job of locating trained and experienced personnel. The office also assists alumni to establish new connections.

The Placement Office, of course, cannot give any graduate a guarantee of employment; however, during the past year this office listed several jobs for every graduate and practically all seniors were placed before Commencement. No official part-time placement program is in operation because of the heavy academic schedule.

COOPERATIVE PLAN

Massachusetts Institute of Technology Lowell Technological Institute

A cooperative arrangement between Lowell Technological Institute and Massachusetts Institute of Technology includes the following major provisions:

- (1) The mutual use of the manufacturing and research facilities for graduate and undergraduate theses;
- (2) The mutual use of textile libraries of both institutions;
- (3) The opportunity for students at each institute to supplement their work by taking work presented at the other institute;
- (4) The formation of joint seminars and the interchange of staff members for special lectures.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Memorial Library, the Research Foundation, and the Summer School program, the college provides such special services to industry and to the community as the following:

Industrial seminars and conferences;

Guidance work in the high schools;

Consultive opportunities with the Faculty;

Collaboration with the International Cooperation Administration of the Government in its foreign aid program;

Special radio and television programs.

For information relative to these programs, address The Coordinator of Special Services, Lowell Technological Institute, Lowell, Massachusetts.

SUMMER SESSION

The Summer Session is designed primarily to serve three principal areas of interest: Professional Advancement Courses for industrial personnel; Undergraduate Credit Courses for college students with course deficiencies; and Precollege Refresher Courses for incoming freshmen at L.T.I.

The industry-sponsored professional advancement program comprises a series of specialized, intensive, one- to three-week courses in textile, paper, and leather technology. The six-week undergraduate credit program stresses fundamental courses in college mathematics, physics, chemistry, English, and economics.

Precollege Refresher Courses

The precollege refresher program is especially designed to articulate the high-school training of prospective L.T.I. students with the more intensive college-level studies in basic mathematics, physics, chemistry, and English. The noncredit refresher courses are offered both in a six-week and a four-week session in order to provide adequate coverage for a number of minor deficiencies in the high-school background.

For further information on the Summer Session, write to Professor Ernest P. James, Director of Summer School.

EVENING DIVISION

The Evening Division offers a wide variety of courses in engineering, chemistry, textiles, rubber, paper, leather, electronics, plastics, the social sciences, and art. These courses are designed to fit the needs of the community, particularly those people engaged in industry who wish to further their education.

The Evening Division offers four-year associate degree courses in chemistry and in electrical, electronic, industrial, and mechanical engineering, also five-year associate degree courses in paper, leather, plastics, and rubber engineering.

Two semesters of 15 weeks each are offered, starting late in September and late in January. For further information, write to the Director of the Evening Division.

Courses of Study

UNDERGRADUATE PROGRAMS

Twelve fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science. These fields are:

- Chemistry
- Electronic Engineering
- Engineering Physics
- General Engineering
- Leather Engineering
- Nuclear Science and Engineering
- Paper Engineering
- Plastics Engineering
- Textile Chemistry
- Textile Engineering—Engineering Option
- Textile Engineering—General Manufacturing Option
- Textile Technology

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary to enable the Institute better to fulfill its mission of service to industry.

In all courses considerable work in practical industrial applications has been included in addition to the fundamental studies in the physical sciences, mathematics, and engineering. Classes in the humanities and social sciences have been woven into all curricula in a conscious effort to produce graduates not only with a thorough technical training but also with the broad cultural background which marks the educated man.

The Freshman Program

Orientation

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating the adjustment of the new student to his physical and social surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All new students are required to attend the program of Freshman Orientation which carries no academic credit but is designed to make the freshman aware of his new responsibilities and to help him adjust to college life. It guides him in making the most efficient use of his time and talents, and it attempts to develop his ability to think and to react thoughtfully and intelligently to new ideas and viewpoints.

Freshman Course of Study

First Semester

*AS	101	Air Science	(2-1)2
CH	101	General Chemistry	(4-2)4
EN	113	Engineering Graphics	(0-3)1
GS	111	English Composition	(3-0)3
MA	107	Introduction to Mathematical Analysis	(4-0)4
PH	103	Physics	(4-1)4

Total credit hours	18
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Second Semester

*AS	102	Air Science	(2-1)2
CH	102	General Chemistry	(4-2)4
EN	114	Engineering Graphics	(0-3)1
GS	112	English Composition	(3-0)3
MA	108	Calculus and Analytic Geometry	(5-0)5
PH	104	Physics	(4-1)4

Total credit hours	19
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In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education for the whole freshman year. This subject meets one hour per week for AFROTC students and two hours per week for all others. It carries no academic credit.

* Required of all able-bodied, nonveteran male citizens (see page 48). Other students must take in its place GS 101-102, Elements of Political and Economic Geography.

The Elective System

In all curricula an opportunity is afforded the student to elect subjects in addition to those required for graduation. These electives fall into two categories: technical electives and general electives.

Technical electives give the student a chance to broaden his professional knowledge by taking subjects allied to his main interest or to further his knowledge of a particular phase by taking additional work therein.

General electives are subjects offered by the Division of General Studies. They include cultural courses in the humanities or social sciences, or management courses to help fit the graduate for positions of executive responsibility. Normally all general electives taken by a student as an undergraduate must be chosen from one of the five cores listed below. However, in particular cases and with the division chairman's permission elective work may be divided between two cores.

- I. Management Core**
 - GS 301 Economic Development of the United States (3-0)3
 - GS 302 Modern Labor Problems (3-0)3
 - GS 461 Personnel Management (3-0)3
 - GS 463 Business Law (3-0)3
 - GS 465 Management Problems Research (3-0)3
- II. Finance Core**
 - GS 307 Principles of Finance and Banking (3-0)3
 - GS 341 Accounting—I (3-0)3
 - GS 342 Accounting—II (3-0)3
 - GS 468 Investment Fundamentals (3-0)3
 - Elective (3-0)3
- III. Sales Core**
 - GS 321 Industrial Marketing (3-0)3
 - GS 322 Industrial Marketing (3-0)3
 - GS 442 Export Sales Management (3-0)3
 - GS 443 Industrial Advertising (3-0)3
 - Elective (3-0)3
- IV. Literature Core**
 - GS 222 Appreciation of Literature (3-0)3
 - GS 233 Comparative Literature (3-0)3
 - GS 473 The Modern American Novel (3-0)3
 - GS 474 Modern Drama (3-0)3
 - Elective (3-0)3
- V. History and Government Core**
 - GS 223 The United States since 1865 (2-0)2
 - GS 226 World History since 1900 (3-0)3
 - GS 301 Economic Development of the United States (3-0)3
 - GS 470 Comparative Modern Governments (3-0)3
 - GS 472 American Foreign Policy, 1774 to the Present (3-0)3

Chemistry

Those who make Chemistry their field of concentration are provided with a basic knowledge of the four major branches of chemistry, inorganic, organic, analytical, and physical, and with advanced instruction in one or more of the same areas, to prepare either for positions in the chemical industry or for further training at the graduate level.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
CH	201M	Organic Chemistry	(3-6)5
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4

Total credit hours 20

*Alternate: General Elective

Second Semester

*AS	202	Air Science	(2-1)2
CH	202M	Organic Chemistry	(3-6)5
CH	206	Qualitative Analysis	(2-6)4
EN	212	Machine Tool Laboratory	(1-2)1
EN	352	Statistical Methods	(3-0)3
PH	206	Physics	(3-2)4

Total credit hours 19

*Alternate: General Elective

JUNIOR YEAR

First Semester

CH	307	Atomic and Molecular Structure	(3-0)3
CH	331	Physical Chemistry	(3-3)4
GS	201	Principles of Economics I	(3-0)3
GS	261	Technical German	(3-0)3
		*General Elective	(3-0)3
		Technical Elective	3

Total credit hours 19

*Alternate: AS 301, Air Science (4-1)4

Second Semester

CH 314	Advanced Quantitative Analysis	(2-4)3
CH 332	Physical Chemistry	(3-3)4
GS 202	Principles of Economics II	(3-0)3
GS 262	Technical German	(3-0)3
	*General Elective	(3-0)3
	Technical Elective	3

Total credit hours 19

*Alternate: AS 302, Air Science (4-1)4

SENIOR YEAR

First Semester

CH 423 or 431 or 443	Advanced Chemistry	(3-0)3
	*Two General Electives	(6-0)6
	Technical Electives	6

Total credit hours 15

*AS 401, Air Science (4-1)4 may be substituted for one General Elective

Second Semester

CH 424 or 432 or 444	Advanced Chemistry	(3-0)3
	*Two General Electives	(6-0)6
	Technical Electives	6

Total credit hours 15

*AS 402, Air Science (4-1) 4 may be substituted for one General Elective

Recommended Technical Electives for juniors and seniors: CH 333, 334, 342, 352, 403-404, 446, and 481; PH 302, 352, and 544 for seniors only; CH 408-409, 423-424, 431-432, and 443-444.

Recommended General Electives: GS 222, 223, 226, 301, 302, 303, 470, 472, 473, and 475.

NOTE: For explanation of the Elective System, see page 57.

Electronic Engineering

The objective of the curriculum in Electronic Engineering is to provide the student with a sound foundation for a professional career in electronics. Toward this end he is given a thorough grounding in electronic science and engineering together with an intensive training in mathematics and physics.

In all courses in electronics and physics the techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture demonstrations in the classroom.

Studies in the humanities and social sciences form an important part of the program since these subjects broaden the student's outlook. They also serve to focus attention on the importance of nontechnical knowledge in determining the student's ultimate level of responsibility in professional life. Emphasis is placed on the development of the student's ability to speak and write effectively so that he can express his thoughts and the results of his experimental investigations with clarity.

In addition to his formal studies, the student is encouraged and expected to do independent reading in philosophy, history, and literature, as well as supplementary work in the areas of his special technical interest.

During each semester of the undergraduate program in Electronic Engineering a case study is made of some novel topic or situation occurring in industry or in the course of an engineer's professional work. This gives the student an opportunity to develop his ability to make reasoned judgments in complex situations wherein nontechnical factors frequently are of paramount importance.

Due to limitations of staff and facilities, only a limited number of students can be accepted in Electronic Engineering. Such acceptance is based upon the student's performance during the freshman year.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
EL	201	Introductory Circuit Theory	(4-0)4
EL	203	Electricity and Magnetism Laboratory	(0-3)1
EL	205	Introductory Field Theory	(4-0)4
GS	223	The United States since 1865	(2-0)2
MA	205	Calculus and Analytic Geometry	(4-0)4

Total credit hours 17

*Alternate: GS 209, 213, 233, 261, 263, or 265 (3-0)3

Second Semester

*AS	202	Air Science	(2-1)2
EL	202	Introductory Circuit Theory	(3-0)3
EL	204	Elementary Electricity and Magnetism Laboratory	(0-3)1
EL	206	Introductory Field Theory	(3-0)3
EL	210	Electronic Circuits	(3-0)3
GS	214	Communication of Ideas	(3-0)3
MA	206	Differential Equations	(3-0)3

Total credit hours 18

*Alternate: GS 210, 222, 224, 226, 234, 262, 264, or 266 (3-0)3

JUNIOR YEAR

First Semester

EL	305	Electronics Laboratory	(0-4)2
EL	309	Physical Basis for Electronic Engineering	(3-0)3
EL	311	Engineering Mathematics	(4-0)4
EL	321	Mechanics	(3-0)3
EL	323	Electronic Circuits	(3-0)3
		*Elective from the list below	<u>3 or 4</u>

Total credit hours 18 or 19

*GS 209, 213, 233, 261, 263, 265, 301, 303, 361, 371; AS 301

Second Semester

EL	306	Electronics Laboratory	(0-4)2
EL	310	Electromagnetics	(3-0)3
EL	312	Engineering Mathematics	(4-0)4
EL	322	Thermodynamics	(3-0)3
EL	324	Network Analysis	(3-0)3
		*Elective from the list below	<u>3 or 4</u>

Total credit hours 18 or 19

*GS 210, 222, 224, 226, 234, 262, 264, 266, 362, 372; AS 302

SENIOR YEAR

First Semester

EL	401	Servomechanisms	(3-0)3
EL	405	Communication Electronics	(3-0)3
EL	411	Applied Electronics Laboratory	(0-4)2
		*Two Technical Electives	<u>6</u>
		†General Elective from the list below	(3-0)3

Total credit hours 17

*AS 401, Air Science (4-0)4 may be substituted for one Technical Elective.

†GS 209, 213, 233, 261, 263, 265, 301, 303, 311, 361, 473

Technical Electives

EL	403	Microwave Electronics	(3-0)3
EL	407	Pulse and Digital Circuits	(3-0)3
EL	409	Electronic Projects Laboratory	(0-4)2
EL	429	Special Topics in Electronics	(3-0)3
EL	433	Solid State Physical Electronics	(3-0)3
EL	435	Instrumentation	(3-0)3
EL	437	Introduction to Scientific Research	(2-0)2

Second Semester

EL	402	Servomechanisms	(3-0)3
EL	406	Communication Electronics	(3-0)3
EL	412	Applied Electronics Laboratory	(0-4)2
		*Two Technical Electives	6
		†General Elective from the list below	(3-0)3

Total credit hours 17

*AS 402, Air Science (4-1)4 may be substituted for one Technical Elective.

†GS 210, 222, 224, 226, 234, 262, 264, 266, 362, 372, 470, 472, 475

Technical Electives

EL	404	Microwave Electronics	(3-0)3
EL	408	Pulse and Digital Circuits	(3-0)3
EL	410	Electronic Projects Laboratory	(0-4)2
EL	430	Special Topics in Electronics	(3-0)3
EL	434	Solid State Physical Electronics	(3-0)3
EL	436	Instrumentation	(3-0)3
EL	440	Experimental Techniques	(1-1)1
GS	314	Philosophy of Science	(3-0)3

NOTE: For explanation of the Elective System, see page 57.

Engineering Physics

This program was developed to meet the demands of industry, education, and government for people with an intensive training in physics and mathematics and the ability to put their knowledge to use in helping to solve some of the problems of the current crisis in science, as researchers or teachers. It is intended to challenge the student to his greatest achievements and should not be contemplated by any who do not find themselves on the best of terms with mathematics.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
GS	261	Technical German	
	or		(3-0)3
GS	265	Elementary Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
PH	211	Intermediate Mechanics	(3-0)3
PH	251	Intermediate Electricity	(3-3)4

Total credit hours 20

*Alternate: General Elective

Second Semester

*AS	202	Air Science	(2-1)2
GS	262	Technical German	
	or		(3-0)3
GS	266	Elementary Russian	
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(3-2)4
PH	222	Intermediate Thermodynamics	(3-0)3
PH	254	Electronics	(3-3)4

Total credit hours 19

*Alternate: General Elective

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
PH	311	Physical Mechanics	(3-0)3
PH	343	Atomic Physics	(3-1)3
PH	353	Electromagnetic Theory	(3-0)3
PH	355	Physical Electronics	(3-3)4
		*General Elective	(3-0)3

Total credit hours 19

*Alternate: AS 301, Air Science (4-1)4

Second Semester

MA 302	Advanced Calculus	(3-0)3
PH 324	Statistical Mechanics	(3-0)3
PH 358	Electrical Measurements	(2-3)3
PH 362	Intermediate Nuclear Physics	(3-0)3
	*Two General Electives	(6-0)6

Total credit hours 18

*AS 302, Air Science (4-1)4 may be substituted for one General Elective

SENIOR YEAR

First Semester

MA 403	Modern Mathematical Methods	(3-0)3
PH 411	Quantum Mechanics	(3-0)3
PH 461	Nuclear Physics	(3-0)3
PH 471	Solid State Physics	(3-0)3
PH 493	Advanced Laboratory	(0-4)1
	*Two General Electives	(6-0)6

Total credit hours 19

*AS 401, Air Science (4-1)4, may be substituted for one General Elective

Second Semester

MA 404	Modern Mathematical Methods	(3-0)3
PH 412	Quantum Mechanics	(3-0)3
PH 462	Nuclear Physics	(3-0)3
PH 472	Solid State Physics	(3-0)3
PH 494	Advanced Laboratory	(0-4)1
	One Technical Elective	3
	*One General Elective	(3-0)3

Total credit hours 19

*Alternate: AS 402, Air Science

(4-1)4

NOTE: For explanation of the Elective System, see page 57.

General Engineering

The General Engineering curriculum is designed to give the student a fundamental preparation for a wide variety of positions in industry, because of industry's growing need for men who are versatile in their engineering capabilities, soundly trained in the basic principles which underlie all engineering, and therefore adaptable to assignment to numerous positions in modern industrial organizations. Notably, the graduates of this curriculum are equipped to deal with electromechanical systems, which are increasingly forming the core of present-day industry.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
EN	203	Mechanism	(2-3)3
EN	221	Applied Mechanics I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
		General Elective	(3-0)3

Total credit hours	19
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*Alternate: General Elective

Second Semester

*AS	202	Air Science	(2-1)2
EN	226	Applied Mechanics II	(3-0)3
EN	232	Engineering Materials	(3-2)4
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(3-2)4
		General Elective	(3-0)3

Total credit hours	19
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*Alternate: General Elective

JUNIOR YEAR

First Semester

EN	211	Machine Tool Laboratory	(1-2)1
EN	303	Electrical Circuits	(3-2)3
EN	305	Thermodynamics	(3-0)3
EN	317	Applied Mechanics III	(3-0)3
		General Elective	(3-0)3
		*Technical Electives	7

Total credit hours	20
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*May include AS 301, Air Science	(4-1)4
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Technical Electives

CH	331	Physical Chemistry	(3-3)4
EN	307	Surveying and Structures	(3-3)4
EN	309	Metals Processing	(2-2)3
EN	313	Advanced Mechanism	(2-2)3
MA	301	Advanced Calculus	(3-0)3

Second Semester

EN	316	Applied Thermodynamics	(3-3)4
EN	344	Electrical Machinery	(3-2)4
PH	352	Electronic Circuits	(3-2)4
		General Elective	(3-0)3
		*Technical Elective	3 or 4

Total credit hours 18 or 19

*Alternate: AS 302, Air Science (4-1)4

Technical Electives

CH	332	Physical Chemistry	(3-3)4
CH	352	Chemical Engineering	(3-0)3
EN	308	Structures	(3-0)3
EN	320	Mechanical Vibrations	(3-0)3
EN	336	Physical Metallurgy	(3-0)3
MA	302	Advanced Calculus	(3-0)3

SENIOR YEAR

First Semester

EN	351	Statistical Methods	(3-0)3
EN	406	Fluid Mechanics	(3-2)4
EN	451	Electromechanical Engineering	(3-3)4
		*General Elective	(3-0)3
		Technical Elective	3 or 4

Total credit hours 17 or 18

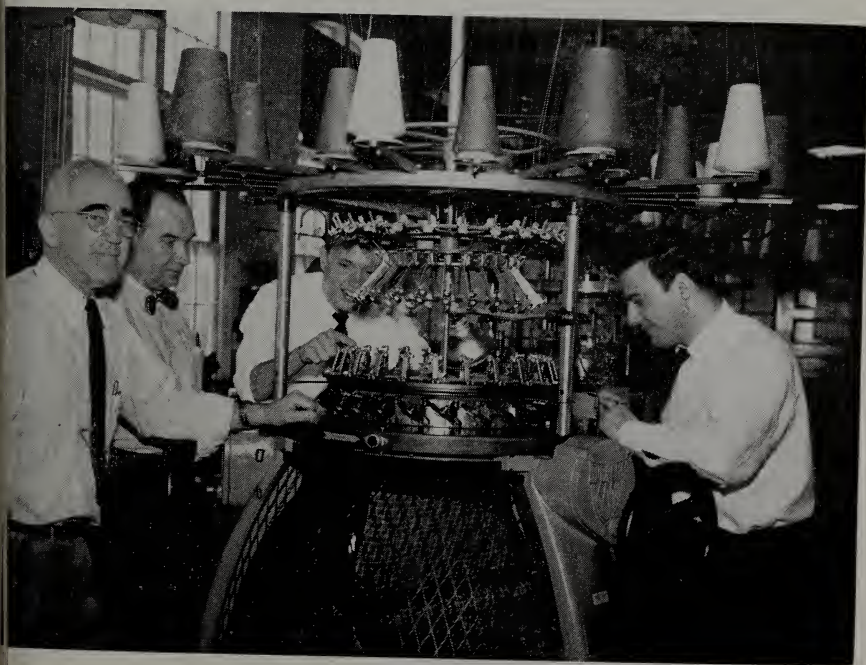
*Alternate: AS 401, Air Science (4-1)4

Technical Electives

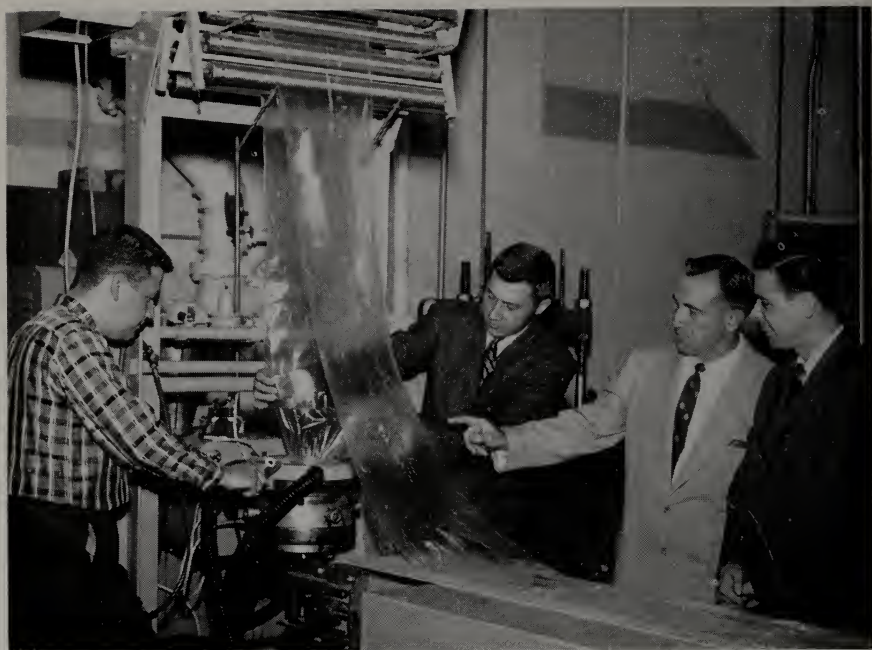
CH	441	Chemical Engineering	(3-0)3
EN	427	Machine Design	(2-3)3
MA	403	Modern Mathematical Methods	(3-0)3
PH	543	Spectrographic Methods	(2-3)3
PH	545	X-Ray Diffraction	(2-3)3



New Field—Nuclear Research



Traditional Course—Knitting



Plastics Engineering Instruction



Air Force ROTC Band at Attention



Crucial Moment on the Court



In Paper Engineering Laboratory



Sorority Plans in the Making



Dorm Residents at Ease



Alumni Memorial Library



Leather Engineering Project



Future Electronic Engineers



Direction from the Placement Office



Morning in the Chem Lab



Evening at the Ball

Second Semester

EN 404	Heat Transfer	(3-0)3
EN 420	Industrial Instrumentation	(2-3)3
EN 452	Electromechanical Engineering	(3-3)4
	*General Elective	(3-0)3
	Technical Electives	6 or 7

Total credit hours 19 or 20

*Alternate: AS 402, Air Science (4-1)4

Technical Electives

EN 412	Advanced Heat Engineering	(2-3)3
EN 428	Machine Design	(2-3)3
EN 442	Air Conditioning	(2-2)2
EN 502	Statistical Quality Control	(3-0)3
EN 506	Methods of Experimental Stress Analysis	(2-3)3
MA 404	Modern Mathematical Methods	(3-0)3
PH 548	Electron Microscopy and Electron Diffraction	(2-3)3

General Electives are to be chosen as follows:

Four or more subjects must be taken from Groups 1 and 2 (below).
At least two subjects must be from Group 1 and one subject from Group 2.

Group 1.

GS 101, 102, 201, 202, 213, 214, 223 or 224, 226, 301, 303, 371 or 372, 470, 472.

Group 2.

GS 222, 233, 234, 265, 266, 473, 475.

NOTE: For explanation of the Elective System, see page 57.

Leather Engineering

The Leather Engineering course has been designed to graduate engineers with a thorough understanding of the art of leather manufacturing, aware that many products of the leather industry can be improved by the application of sound and intelligent research and development. The economics, size, and scope of the leather industry warrant the careful training of individuals capable of handling its specific problems.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
CH	201	Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(2-6)4
EN	325	Applied Mechanics	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4

Total credit hours 21

*Alternate: GS 201, Principles of Economics I (3-0)3

Second Semester

*AS	201	Air Science	(2-1)2
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
EN	352	Statistical Methods	(3-0)3
LE	202	Applied Leather Analysis	(1-4)2
		General Elective	(3-0)3

Total credit hours 19

*Alternate: GS 202, Principles of Economics II (3-0)3

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
EN	331	Strength of Materials	(3-0)3
*GS	341	Accounting I	(3-0)3
LE	301	Leather Technology	(3-6)5
LE	303	Leather Histology	(2-4)4

Total credit hours 19

*Alternate: AS 301, Air Science (4-1)4

Second Semester

CH 332	Physical Chemistry	(3-3)4
CH 334	General Colloid Chemistry	(3-0)3
LE 302	Leather Technology	(3-6)5
LE 304	Leather Microbiology	(2-4)4
	*General Elective	(3-0)3

Total credit hours 19

*Alternate: AS 302, Air Science (4-1)4

SENIOR YEAR

First Semester

LE 401	Leather Technology	(3-6)5
LE 405	Leather Seminar	(1-0)1
LE 411	Leather Problems	(1-6)3
PH 351	Electronic Circuits	(3-1)3
	*Two General Electives	(6-0)6

Total credit hours 18

*AS 401, Air Science (4-1)4 may be substituted for one elective.

Second Semester

EN 344	Electrical Machinery	(3-2)4
LE 402	Leather Technology	(3-6)5
LE 404	Properties of Leather	(2-3)3
LE 406	Leather Seminar	(1-0)1
LE 412	Leather Problems	(1-6)3
	*General Elective	(3-0)3

Total credit hours 19

*Alternate: AS 402, Air Science (4-1)4

NOTE: For explanation of the Elective System, see page 57.

Nuclear Science and Engineering

The program in Nuclear Science and Engineering, first to be offered by a publicly supported institution in New England, is planned to give the graduates a broad engineering education, with sufficient grounding in the specialized nuclear field to enable them to accept positions of responsibility and leadership in this rapidly growing industry.

Prototype Curriculum

SOPHOMORE YEAR

Similar to curriculum in Engineering Physics

JUNIOR YEAR

First Semester		Second Semester	
Advanced Calculus	(3-0)3	Advanced Calculus	(3-0)3
Atomic Physics	(3-0)3	Intermediate Nuclear Physics	(3-0)3
Physical Mechanics	(3-0)3	Shielding and Safety	(2-2)3
Electrical Measurements	(2-3)3	Electronic Pulse Techniques	(3-3)4
Radiochemistry	(2-3)3	Physical Metallurgy	(3-0)3
Radiation Physics	(1-0)1	Radiation Physics	(1-0)1
Humanities Elective	(3-0)3	Humanities Elective	(3-0)3

SENIOR YEAR

First Semester		Second Semester	
Modern Mathematical Methods	(3-0)3	Solid State Physics	(3-0)3
Quantum Mechanics	(3-0)3	Heat Transfer	(3-0)3
Nuclear Physics	(3-0)3	Nuclear Physics	(3-0)3
Nuclear Reactor Instrumentation	(2-3)3	Reactor Studies	(2-3)3
Fluid Mechanics	(3-0)3	Nuclear Particle Instrumentation	(2-3)3
Advanced Laboratory	(0-4)1	Advanced Laboratory	(0-4)1
Elective	(3-0)3	Elective	(3-0)3

Paper Engineering

The object of the Paper Engineering course is to fit a man for work in the papermaking, paper-converting, or allied industries. A thorough training in basic chemical engineering is offered, accompanied by instruction in the theory and practice of pulp and paper manufacture and paper converting. Paper engineering involves the application of cellulose and plastics chemistry together with engineering principles to the handling of the material in the web or sheet form, as it is treated, coated, or converted into the final product.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4

Total credit hours 19

*Alternate: General Elective

Second Semester

*AS	202	Air Science	(2-1)2
CH	202	Organic Chemistry	(3-3)4
CH	290	Introduction to Chemical Engineering	(3-3)4
EN	326	Applied Mechanics	(3-0)3
EN	352	Statistical Methods	(3-0)3
GS	214	Communication of Ideas	(3-0)3

Total credit hours 19

*Alternate: General Elective

SUMMER

PA	408	Mill Inspection Trip	No credit
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JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
CH	333	Industrial Stoichiometry	(3-0)3
EN	331	Strength of Materials	(3-0)3
*GS	213	Technical Scientific Writing	(3-0)3
PA	301	Pulp Technology	(3-0)3
PA	303	Pulp Laboratory	(2-6)4

Total credit hours 20
(4-1)4

*Alternate: AS 301, Air Science

Second Semester

CH 332	Physical Chemistry	(3-3)4
CH 334	General Colloid Chemistry	(3-0)3
CH 352	Chemical Engineering	(3-0)3
PA 302	Paper Technology	(3-0)3
PA 304	Paper Laboratory	(2-6)4
	*General Elective	(3-0)3

Total credit hours	20
	(4-1)4

*Alternate: AS 302, Air Science

SUMMER

PA 409	Mill Inspection Trip	No credit
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SENIOR YEAR

First Semester

CH 441	Chemical Engineering	(3-0)3
EN 405	Electronic Controls and Power Circuits	(3-2)4
PA 403	Converting Technology	(3-0)3
PA 405	Converting Laboratory	(2-6)4
PA 411	Wood Chemistry	(3-0)3
	*General Elective	(3-0)3

Total credit hours	20
	(4-1)4

*Alternate: AS 401, Air Science

Second Semester

CH 442	Chemical Engineering Thermodynamics	(3-0)3
EN 420	Industrial Instrumentation	(2-3)3
PA 414	Paper Problems	(2-6)4
	Two Technical Electives	6
	*General Elective	(3-0)3

Total credit hours	19
	(4-1)4

*Alternate: AS 402, Air Science

NOTE: For explanation of the Elective System, see page 57.

Plastics Engineering

The training of engineers specifically prepared to cope with the many technical and production problems found in the expanding field of plastics fabrication is the objective of the course in Plastics Engineering. Emphasis is on the engineering principles involved in the fabrication of plastics materials into useful forms rather than the chemistry involved in the manufacture of the plastics material itself. However, the curriculum involves considerably more chemistry than most engineering courses, owing to the close relationship between the physical and chemical properties of such materials. Problems of design, manufacture, and testing in the plastics industry are closely studied.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
CH	201	Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(2-6)4
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
PL	201	Plastics Technology I	(2-0)2

Total credit hours	20
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*Alternate: General Elective

Second Semester

*AS	202	Air Science	(2-1)2
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
EN	352	Statistical Methods	(3-0)3
PH	206	Physics	(3-2)4
PL	202	Plastics Technology I	(2-0)2

Total credit hours	20
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*Alternate: General Elective

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
EN	211	Machine Tool Laboratory	(1-2)1
EN	325	Applied Mechanics	(3-0)3
EN	405	Electronic Controls and Power Circuits	(3-2)4
*GS	201	Principles of Economics I	(3-0)3
PL	301	Plastics Technology II	(2-2)3

Total credit hours	18
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*Alternate: AS 301, Air Science	(4-1)4
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Second Semester

CH 332	Physical Chemistry	(3-3)4
EN 232	Engineering Materials	(3-2)4
EN 234	Plastics Mold Design and Construction	(1-2)1
EN 332	Strength of Materials	(3-0)3
*GS 202	Principles of Economics II	(3-0)3
PL 302	Plastics Technology II	(2-2)3
		Total credit hours 18
*Alternate: AS 302, Air Science		(4-1)4

SENIOR YEAR

First Semester

CH 403	Chemistry of High Polymers	(3-3)4
PL 401	Plastics Technology III	(2-3)3
PL 403	Properties of Polymers	(2-3)3
PL 411	Plastics Seminar	(1-0)1
	*Two electives	(6-0)6
		Total credit hours 17
*AS 401, Air Science (4-1)4 may be substituted for one elective		

Second Semester

CH 404	Chemistry of High Polymers	(3-3)4
EN 408	Fluid Mechanics	(3-0)3
EN 422	Industrial Instrumentation	(2-0)2
PL 402	Plastics Technology III	(2-3)3
PL 404	Properties of Polymers	(2-3)3
PL 412	Plastics Seminar	(1-0)1
	*Elective	(3-0)3
		Total credit hours 19
*Alternate: AS 402, Air Science		(4-1)4

Electives

CH 307	Atomic and Molecular Structure	(3-0)3
CH 423-424	Advanced Organic Chemistry	(3-0) (3-0)6
EN 203	Mechanism	(2-3)3
EN 502	Statistical Quality Control	(3-0)3
EN 509		
or	Advanced Statistical Methods	(3-0)3
EN 510		
GS 261-262	Technical German	(3-0) (3-0)6
MA 206	Differential Equations	(3-0)3

NOTE: For explanation of the Elective System, see page 57.

Textile Chemistry

A sound foundation in basic chemistry and a knowledge of chemical applications in textiles and in textile processes are combined in the Textile Chemistry course to provide a specialized training for chemists planning to work in the textile industry or in related chemical industries producing auxiliary chemicals and fibers.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
CH	201M	Organic Chemistry	(3-6)5
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4

Total credit hours 20

*Alternate: General Elective

Second Semester

*AS	202	Air Science	(2-1)2
CH	202M	Organic Chemistry	(3-6)5
CH	206	Qualitative Analysis	(2-6)4
EN	212	Machine Tool Laboratory	(1-2)1
EN	352	Statistical Methods	(3-0)3
PH	206	Physics	(3-2)4

Total credit hours 19

*Alternate: General Elective

JUNIOR YEAR

First Semester

CH	311	Advanced Quantitative Analysis for Textile Chemists	(2-4)3
CH	331	Physical Chemistry	(3-3)4
CH	355	Chemistry and Physics of Fibers	(3-3)4
GS	201	Principles of Economics I	(3-0)3
TE	321	Elements of Textiles: Yarns	(2-3)3
		*General Elective	(3-0)3

Total credit hours 20

*Alternate: AS 301, Air Science (4-1)4

Second Semester

CH 332	Physical Chemistry	(3-3)4
CH 356	Chemistry of Fiber Purification	(2-3)3
CH 364	Textile Colloid Chemistry	(4-0)4
GS 202	Principles of Economics II	(3-0)3
TE 334	Elements of Textiles: Fabrics	(2-3)3
	*General Elective	(3-0)3

Total credit hours 20

*Alternate: AS 302, Air Science (4-1)4

SENIOR YEAR

First Semester

CH 425	Organic Chemistry of Colored Substances	(2-0)2
CH 453	Theory of Dyeing	(3-4)4
TE 455	Chemical Technology of Finishing I	(2-1)2
TE 457	Chemical Technology of Finishing II	(2-1)2
TE 471	Testing of Textiles I	(2-3)3
	*Electives	6

Total credit hours 19

*AS 401, Air Science (4-1)4 may be taken as one elective.

Second Semester

CH 422	Chemical Textile Testing	(2-3)3
CH 454	Industrial Dyeing and Printing	(2-8)4
TE 456	Chemical Technology of Finishing I	(1-2)2
TE 458	Chemical Technology of Finishing II	(1-2)2
	*Electives	6

Total credit hours 17

*AS 402, Air Science (4-1)4 may be taken as one elective.

Recommended technical electives are: CH 333, 334, 342, 352, 403-404, 408, 409, 423-424, 431-432, 443-444, 446, 481; MA 206; PH 302, 352, 544.

NOTE: For explanation of the Elective System, see page 57.

Textile Engineering

Engineering Option

A textile engineer is one who has had a basic training in engineering to which has been added a knowledge of the manufacture of textiles, their properties and uses. The Engineering Option of Textile Engineering provides a training in mechanical engineering similar to that found in other engineering schools, plus a knowledge of textiles sufficient to prepare the individual for a position in the textile and allied industries which may involve research and engineering principles.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
EN	203	Mechanism	(2-3)3
EN	221	Applied Mechanics I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
		General Elective	(3-0)3

Total credit hours 19

*Alternate: General Elective

Second Semester

*AS	202	Air Science	(2-1)2
EN	226	Applied Mechanics II	(3-0)3
EN	232	Engineering Materials	(3-2)4
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(3-2)4
		General Elective	(3-0)3

Total credit hours 19

*Alternate: General Elective

JUNIOR YEAR

First Semester

EN	211	Machine Tool Laboratory	(1-2)1
EN	305	Thermodynamics	(3-0)3
EN	317	Applied Mechanics III	(3-0)3
EN	351	Statistical Methods	(3-0)3
PH	351	Electronic Circuits	(3-1)3
TE	381	Principles of Textile Operations I	(4-4)4
		*General Elective	(3-0)3

Total credit hours 20

*Alternate: AS 301, Air Science (4-1)4

Second Semester

EN 316	Applied Thermodynamics	(3-3)4
EN 320	Mechanical Vibrations	(3-0)3
EN 342	Principles of Electrical Engineering	(3-2)4
TE 352N	Principles of Textile Operations II	(3-3)4
	*General Elective	(3-0)3

Total credit hours 18

*Alternate: AS 302, Air Science (4-1)4

SENIOR YEAR

First Semester

EN 401	Principles of Electrical Engineering	(3-2)4
EN 407	Fluid Mechanics	(3-0)3
TE 471	Testing of Textiles I	(2-3)3
TE 483	Engineering Design of Textile Structures	(3-0)3
	*One Technical Elective and one General Elective	6

Total credit hours 19

*AS 401, Air Science (4-1)4 may be substituted for the Technical Elective.

Technical Electives

EN 427	Machine Design	(2-3)3
EN 505	Methods of Experimental Stress Analysis	(2-3)3
PH 543	Spectrographic Methods	(2-3)3
PH 545	X-Ray Diffraction	(2-3)3

Second Semester

EN 404	Heat Transfer	(3-0)3
EN 420	Industrial Instrumentation	(2-3)3
TE 482	Application of Scientific Methods to Textile Processes	(3-0)3
TE 484	Engineering Design of Textile Structures	(3-0)3
	*One Technical Elective and one General Elective	6

Total credit hours 18

*AS 402, Air Science (4-1)4 may be substituted for the Technical Elective.

Technical Electives

EN 428	Machine Design	(2-3)3
EN 442	Air Conditioning	(2-2)2
PH 548	Electron Microscopy and Electron Diffraction	(2-3)3
TE 472	Testing of Textiles II	(2-3)3

General Electives are to be chosen as follows:

Four or more subjects must be taken from Groups 1 and 2 (below).
At least two subjects must be from Group 1 and one subject from Group 2.

Group 1.

GS 101, 102, 201, 202, 213, 214, 223 or 224, 226, 301, 303, 371 or 372, 470, 472.

Group 2.

GS 222, 233, 234, 265, 266, 473, 475.

NOTE: For explanation of the Elective System, see page 57.

Textile Engineering

General Manufacturing Option

The objective of the General Manufacturing Option of Textile Engineering is to provide the textile industry with technically trained textile engineers. Students in this program are given as complete a knowledge as possible of the raw materials, machines, and processes peculiar to the manufacture of all fibers as well as a basic training in engineering and the fundamental sciences. The course prepares the students to be useful in any textile plant, regardless of fiber processed, approaching textile problems from an engineering viewpoint.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
CH	203	Elementary Organic Chemistry	(3-0)3
EN	203	Mechanism	(2-3)3
EN	221	Applied Mechanics I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4

Total credit hours 19

*Alternate: General Elective

Second Semester

*AS	202	Air Science	(2-1)2
EN	212	Machine Tool Laboratory	(1-2)1
EN	226	Applied Mechanics II	(3-0)3
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(3-2)4
TE	200	Textile Fibers	(4-0)3
TE	210	Fundamentals of Yarns	(2-1)2

Total credit hours 18

*Alternate: General Elective

JUNIOR YEAR

First Semester

EN	317	Applied Mechanics III	(3-0)3
EN	403	Principles of Heat Engineering	(3-2)4
GS	213	Technical and Scientific Writing	(3-0)3
PH	351	Electronic Circuits	(3-1)3
TE	319N	Yarns: Cotton and Filament Systems	(3-3)3
		*General Elective	(3-0)3

Total credit hours 19

*Alternate: AS 301, Air Science (4-1)4

Second Semester

CH 302	Introduction to Textile Chemistry	(1-3)2
EN 344	Electrical Machinery	(3-2)4
EN 352	Statistical Methods	(3-0)3
TE 320	Yarns: Woolen and Worsted Systems	(3-3)3
TE 332	Fundamentals of Fabrics	(4-4)4
	*General Elective	(3-0)3

Total credit hours 18

*Alternate: AS 302, Air Science (4-1)4

SENIOR YEAR

First Semester

EN 407	Fluid Mechanics	(3-0)3
TE 451	Technology of Finishing I	(2-1)2
TE 453	Technology of Finishing II	(2-1)2
TE 471	Testing of Textiles I	(2-3)3
TE 483	Engineering Design of Textile Structures	(3-0)3
	*One Technical Elective and one General Elective	6

Total credit hours 19

*AS 401, Air Science (4-1)4 may be substituted for the Technical Elective.

Technical Electives

EN 427	Machine Design	(2-3)3
EN 505	Methods of Experimental Stress Analysis	(2-3)3
PH 543	Spectrographic Methods	(2-3)3
PH 545	X-Ray Diffraction	(2-3)3
TE 571	Textile Microscopy	(2-3)3

Second Semester

EN 424	Instrumentation for Textiles	(2-2)3
TE 452	Technology of Finishing I	(0-2)1
TE 454	Technology of Finishing II	(0-2)1
TE 472	Testing of Textiles II	(2-3)3
TE 482	Application of Scientific Methods to Textile Processes	(3-0)3
	*One Technical Elective and one General Elective	6

Total credit hours 17

*AS 402, Air Science (4-1)4 may be substituted for the Technical Elective.

Technical Electives

EN	404	Heat Transfer	(3-0)3
EN	428	Machine Design	(2-3)3
EN	442	Air Conditioning	(2-2)2
PH	548	Electron Microscopy and Electron Diffraction	(2-3)3
TE	484	Engineering Design of Textile Structures	(3-0)3

General Electives are to be chosen as follows:

Four or more subjects must be taken from Groups 1 and 2 (below). At least two subjects must be from Group 1 and one subject from Group 2.

Group 1.

GS 101, 102, 201, 202, 213, 214, 223 or 224, 226, 301, 303, 371 or 372, 470, 472.

Group 2.

GS 222, 233, 234, 265, 266, 473, 475.

NOTE: For explanation of the Elective System, see page 57.

Textile Technology

This course of study is designed to equip its students with a well-rounded understanding of the theory and principles relating to the processing of textile materials. At the same time it provides the scientific basis necessary to understand and apply this technological knowledge. Basic purpose of the program is to prepare students to become competent textile technologists for eventual supervisory, administrative, or executive positions within the industry and its allied fields. To achieve this end, a comprehensive course covers the basic theory, principles, and applications of the major phases of textile manufacture utilizing all the common fibers, both natural and man-made, and all fabricating processes.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-1)2
CH	203	Elementary Organic Chemistry	(3-0)3
EN	205	Mechanism	(2-2)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
TE	201N	Technology of Fibers	(3-1)3
Total credit hours			19
*Alternate: GS 223, The United States since 1865			(2-0)2

Second Semester

*AS	202	Air Science	(2-1)2
EN	212	Machine Tool Laboratory	(1-2)1
GS	214	Communication of Ideas	(3-0)3
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(3-2)4
TE	202N	Mechanical and Chemical Properties of Fibers	(3-0)3
TE	210	Fundamentals of Yarns	(2-1)2
Total credit hours			18
*Alternate: GS 224, The United States since 1865			(2-0)2

JUNIOR YEAR

First Semester

EN	311	Heat and Power	(2-2)3
EN	351	Statistical Methods	(3-0)3
*GS	201	Principles of Economics I	(3-0)3
TE	311N	Woolen System Yarns	(3-3)3
TE	313	Worsted System Yarns	(3-3)3
TE	315	Cotton System Yarns	(4-4)4
Total credit hours			19
*Alternate: AS 301, Air Science			(4-1)4

Second Semester

CH	302	Introduction to Textile Chemistry	(1-3)2
*GS	202	Principles of Economics II	(3-0)3
PH	352	Electronic Circuits	(3-1)3
TE	314	Worsted System Yarns	(3-3)3
TE	316	Cotton System Yarns	(3-3)3
TE	318	Filament System Yarns	(1-1)1
TE	330	Mechanics of Fabric Design I	(4-4)4

Total credit hours 19

*Alternate: AS 302, Air Science (4-1)4

SENIOR YEAR

First Semester

CH	401	Introduction to Textile Chemistry	(1-3)2
*GS	303	Psychology	(3-0)3
TE	431N	Mechanics of Fabric Design II	(4-4)4
TE	433	Technology of Woven Fabrics I	(3-3)3
TE	451	Technology of Finishing I	(2-1)2
TE	453	Technology of Finishing II	(2-1)2
TE	471	Testing of Textiles I	(2-3)3

Total credit hours 19

*Alternate: AS 401, Air Science (4-1)4

Second Semester

EN	424	Instrumentation for Textiles	(2-2)3
*GS	470	Comparative Modern Governments	(3-0)3
TE	434N	Technology of Woven Fabrics II	(3-3)3
TE	436	Technology of Knitted Fabrics	(3-3)3
TE	438	Color Theory	(1-1)1
TE	452	Technology of Finishing I	(0-2)1
TE	454	Technology of Finishing II	(0-2)1
TE	472	Testing of Textiles II	(2-3)3

Total credit hours 18

*Alternate: AS 402, Air Science (4-1)4

NOTE: For explanation of the Elective System, see page 57.

Subject Descriptions

Subjects are listed alphabetically, regardless of the department involved, under the following headings:

AS	Air Science	LE	Leather
CH	Chemistry	MA	Mathematics
EL	Electronics	PA	Paper
EN	Engineering	PH	Physics
GS	General Studies	PL	Plastics
	TE		Textiles

The number following the letter symbols is composed of three digits. The first digit of the number indicates the college year when the subject is normally presented, e.g.: GS 111 is a freshman-year subject; PA 414 is a senior-year subject. Subjects numbered 500 and above are restricted to graduate students.

First-semester subjects are designated by odd numbers and second-semester subjects by even numbers. Hyphenated numbers indicate subjects continuing throughout the year.

Following the names of the individual subjects, the number of lecture-recitation and laboratory hours is indicated within the parentheses and the credit hour is shown outside. In the case of a year course the credit shown is the total for the year.

Examples of the above coding are as follows:

(2-6)4 means 2 hours of lecture-recitation and 6 hours of laboratory for 4 credits; (2-3)(1-6)6 indicates 2 hours of lecture-recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture-recitation and 6 hours of laboratory the second semester, for a total credit of 6.

The prerequisites for the various subjects are shown in brackets, e.g., [EN 111]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

AIR SCIENCE

AS 101-102 Air Science I (2-1)(2-1)4

Introduction to Air Force ROTC, elements and potentials of air power, air vehicles and principles of flight, the military instrument of national security, and professional opportunities in the United States Air Force. Classes in leadership and drill provide for the development in the student of the qualities of leadership and discipline essential to Air Force officers.

AS 201-202 Air Science II (2-1)(2-1)4

Introduction to the elements and potentials of air power. The course considers air power in terms of targets, weapons, aircraft, bases, and operations. Consideration is also given to the USAF Officer Career Program and the moral responsibility of Air Force leaders.

AS 301-302 Air Science III (4-1)(4-1)8

Concerns the development of certain specialized intellectual skills in the areas of military law, command and staff, problem solving, communication, and instruction in the Air Force, and certain technical skills in the areas of weather, navigation, and air base functions.

AS 401-402 Air Science IV (4-1)(4-1)8

Seminar in principles of personnel management. The framework of international politics, world powers and strategic areas, and the security problem in relation to international power clashes. Principles of warfare and a historical survey of air warfare. Briefing for commissioned service and a leadership laboratory.

CHEMISTRY

CH 101-102 General Chemistry (4-2)(4-2)8

Chemical principles and calculations. Includes the chemistry of both metallic and nonmetallic elements and of their compounds. A brief survey of organic chemistry is included in the second semester.

CH 201-202 Organic Chemistry (3-3)(3-3)8
[CH 102]

The classification, nomenclature, structure, mechanism of reaction, and behavior in bulk of important kinds of organic species. The laboratory work illustrates the experimental techniques which can be used to react, purify, characterize, and identify organic substances.

CH 201M-202M Organic Chemistry (3-6)(3-6)10
[CH 102]

Identical with CH 201-202 except that additional laboratory work in synthetic organic chemistry is given. Required for majors in chemistry.

CH 203 Elementary Organic Chemistry (3-0)3
[CH 102]

This subject enables students not majoring in chemistry to become conversant with the names, structural formulas, properties and uses of some important industrially available organic substances and with the role which organic chemistry plays in industry and engineering.

CH 205 and 206 Qualitative Analysis (2-6)4
[CH 102]

Mass action principles and systematic analysis of inorganic compounds by semi-micro technique. Offered both semesters.

CH 211 and 212 Quantitative Analysis (3-6)5
[CH 102]

The fundamental principles of quantitative analysis. The principles and calculations of gravimetric analysis, including an introduction to mineral separations as well as the analysis of soluble salts; the principles and calculations of volumetric analysis, including neutralization methods, oxidation-reduction methods, and iodometric methods. Offered both semesters.

CH 290 Introduction to Chemical Engineering (3-3)4

[CH 211]

An introductory study of the principles of material and energy balance, equilibrium, and rate of reaction. Examples are studied in the laboratory. The student is encouraged to develop his initiative and resourcefulness in obtaining experimental data, analyzing results, and communicating his findings by written and oral reports.

CH 302 Introduction to Textile Chemistry (1-3)2

[CH 102]

Lectures for the non-chemist on the various processes preliminary to dyeing. The preliminary treatments given the natural and manufactured fibers are studied as well as the action and properties of the textile chemicals used in these processes.

CH 307 Atomic and Molecular Structure (3-0)3

[CH 102]

Modern concepts of atomic and molecular structures as interpreted through emission, ultraviolet, infrared, and Raman spectra.

CH 311 Advanced Quantitative Analysis for (2-4)3
Textile Chemists

[CH 211 or 212]

The examination and evaluation of chemicals utilized in the textile industry. Advanced techniques and instrumental methods are introduced for the analysis of bleaching agents, industrial water, soaps, oils, and synthetic detergents. Group projects and report writing. For students in the Textile Chemistry course.

CH 314 Advanced Quantitative Analysis (2-4)3

[CH 211 or 212]

Advanced principles and techniques of analytical separations with laboratory emphasis on some instrumental methods. The following topics will be considered: fractional precipitation methods, colorimetry, chromatography, compleximetry, potentiometric titrations, polarography, and organic precipitating agents. Group projects and report writing. For students in the Chemistry course.

CH 331-332 Physical Chemistry
Eng. Phys. (3-1½)(3-3)8
Others (3-3)(3-3)8

[CH 102, MA 205, PH 205]

The formulation and development of the mathematical and mechanical models of theoretical chemistry and their uses in the solution of the practical problems of chemistry and chemical

engineering. Topics included are atomic and molecular structure, states of matter, thermodynamics, thermochemistry solutions, electrochemistry, colloids, chemical equilibrium, kinetics, and photochemistry. CH 331 is for students not majoring in chemistry.

CH 333 Industrial Stoichiometry (3-0)3

[CH 211 or 212, PH 205]

A study of some important operations in the chemical industry, e.g., sulfuric acid, and in the pulp and paper industry from the standpoint of the application of reaction rate and mass and energy balance to the prediction of performance, yield, etc. Recirculatory processes are also studied.

CH 334 General Colloid Chemistry (3-0)3

[CH 331]

The approach is from the standpoint of the theoretical properties of the colloid system. Interfacial phenomena, particle kinetics, electrical properties, and viscosity characteristics are studied. The preparation of colloid solutions and the character of lyophobic and lyophilic sols, gels and emulsions are developed from the above fundamental properties.

CH 342 Organic Qualitative Analysis (1-6)3

[CH 202; CH 205 or 206]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 352 Chemical Engineering (3-0)3

[CH 102, CH 331, MA 206, PH 206]

Descriptive and quantitative information on unit conversion, dimensional analysis, materials of construction, flow of fluids, flow of heat, hygrometry, humidification, dehumidification, and drying.

CH 355 Chemistry and Physics of Fibers (3-3)4

[CH 202 and 211]

The structure and chemical reactions of linear high polymers of importance in the field of natural and synthetic fibers; the chemical and physical structure of polymers and fibers; the relation of molecular length, orientation, crystallinity, intermolecular attractions, side chains, and flexibility of polymers to the physical properties of fibers; chemical reactions of polymers and their effects on fibers.

CH 356 Chemistry of Fiber Purification (2-3)3
[CH 202 and 211]

A study of the impurities present in textile fibers and fabrics and their removal. Both natural and manufactured fibers are taken up. This subject is covered by lecture, laboratory and pilot plant work.

CH 364 Textile Colloid Chemistry (4-0)4
[CH 331]

Basic principles of surface and colloidal chemistry and their applications in industry. Special emphasis is placed on applications to the textile field: wetting, detergency, and finishing processes, as well as the colloidal behavior of the fibers themselves.

CH 401 Introduction to Textile Chemistry (1-3)2
[CH 302]

A continuation of CH 302. The application of various classes of dyes to natural and manufactured fibers. Methods of dyeing, fastness properties of different classes of dyes, and the nature and use of dyeing assistants are stressed.

CH 403-404 Chemistry of High Polymers (3-3)(3-3)8
[CH 202 and 332]

Definition and classification of high polymers; chemistry of the more important polymers including preparation, physical properties, and chemical properties; mechanism and procedures for polymerization, copolymerization, and condensation; physicochemical investigations including molecular weight determination and distribution; the structure of high polymers including relationship of structure to properties; inter- and intra-molecular forces; states of aggregation; transition points; elasticity; viscoelastic behavior; cross-linking; plasticization (internal and external); solvent action.

**CH 408 and/or 409 Advanced Studies Credits to be arranged
in Chemistry**

[Permission of the Chairman of the Chemistry Division and the instructor]

Advanced work in analytical, organic, inorganic, physical, or textile chemistry. Includes literature survey, laboratory work, and reports.

CH 422 Chemical Textile Testing (2-3)3
[CH 356 and 364]

Chemical methods of textile testing. Quantitative as well as qualitative determination of fiber content, finishing agents and dyestuffs. Includes optical methods of analysis and evaluation.

CH 423-424 Advanced Organic Chemistry (3-0)(3-0)6
[CH 202]

Extension of first-year organic chemistry to include additional classes of compounds and special topics. Emphasis is placed on synthetic methods including the mechanism, scope, and limitations of the important name reactions in the field of synthetic organic chemistry.

CH 425 Organic Chemistry of Colored Substances (2-0)2
[CH 201]

The relation between the structure of an organic molecule or ion and its absorption in the ultraviolet or visible spectral region. The synthesis and reactions of selected colored organic substances.

CH 431-432 Advanced Physical Chemistry (3-0)(3-0)6
[CH 314 and 332]

An extension of introductory physical chemistry for majors in chemistry and related fields. Includes additional work in chemical thermodynamics, kinetics, and equilibrium as they apply to the various chemical phenomena with emphasis on the use of chemical literature, methods of treating data, and problem-solving.

CH 441 Chemical Engineering (3-0)3
[CH 352]

A continuation of CH 352. The unit operations of evaporation, gas absorption, filtration, and washing.

CH 442 Chemical Engineering Thermodynamics (3-0)3
[CH 332]

A study of the first law of thermodynamics. Heat capacity, perfect gases, phase rule, and generalized pressure, volume, and temperature relations. An introduction to the second law.

CH 443-444 Advanced Inorganic Chemistry (3-0)(3-0)6
[CH 202 and 314]

Graduate credit allowed

Advanced chemistry of the common elements and their compounds, including coordination complexes, inorganic stereoisomerism, ion exchange, etc.

CH 446 Advanced Inorganic Chemistry Laboratory (0-3)1
[CH 202 and 314]

Inorganic preparations and advanced techniques.

CH 453 **Theory of Dyeing** **(3-4)4**
 [CH 355 and 364]

Mechanisms of reactions in the dyeing of cellulose, cellulose acetate, protein, polyamide, polyester, and polyacrylonitrile fibers. Emphasizes basic physical and chemical variables affecting equilibria and rates of dyeing, diffusion and adsorption. In the laboratory, principles of transmission and reflectance spectrophotometric measurement are employed in kinetic and equilibrium studies.

CH 454 Industrial Dyeing and Printing (2-8)4
[CH 453]

A study of the technology of dyeing and printing the commercially important natural and synthetic fibers using the principal classes of dyes. Includes methods of application, color and color matching, dyestuff properties, and economics of dyeing processes. Principles of design and use of important industrial units are illustrated by pilot plant experiments. Engineering aspects of circulation, agitating, and heat exchange are considered, and the effect of these variables in the dyeing of printing processes is illustrated.

CH 461 Microbiology (1-3)2
[CH 202]

This subject considers the fundamentals of mycological and bacteriological theory briefly but in sufficient detail so that the problem of the microbiological deterioration of textiles, paper, and leather may be discussed. Methods of detecting mildewing, methods of testing textiles for mildew resistance, and bacteriological water analysis are also studied.

CH 464 Advanced Microbiology (1-3)2
[CH 461]

Work is arranged according to the particular interests of the student and consists of special projects.

CH 473 or 474 General Biochemistry (2-4)4
[CH 201-202 or permission of instructor]

The chemistry and metabolism of carbohydrates, proteins and fats, and their products.

CH 475 or 476 General Bacteriology (2-4)4
[CH 201-202 or permission of instructor]

The fundamentals of bacteriology, covering the morphology, physiology, and pure culture characteristics of bacteria.

CH 481 Nuclear Chemistry and Radiochemistry (2-3)3
[CH 332]

The theory and practice of nuclear chemistry and radiochemistry.

CH 491 Textile Chemistry Literature Seminar (2-0)2
[Permission of instructor]

A study and discussion of current textile chemistry literature, stressing the critical analysis of the subject matter.

CH 501 **Color Measurement** **(1-3)2**
[CH 422 or equivalent]

Theory and application of adsorption spectrophotometry to the qualitative and quantitative analyses of colored substances in both transparent and opaque media in the ultraviolet, visible, and near infrared ranges. Includes theories of color, vision, and subjective color evaluation.

CH 503 Interpretation of Data (2-0)2

Mathematical methods of analyzing, plotting, and interpreting experimental data. Lectures and exercises.

CH 505 Physical Chemistry of Dyeing (2-3)3

A combination of lectures, seminars, and laboratory experiments on the physicochemical principles involved in the application of dyestuffs to textile materials.

CH 507-508 **Chemistry Seminar** **(1-0)(1-0)2**

CH 512 The Physical Chemistry of (2-0)2
Surface-active Agents
[CH 364]

A series of lectures on the physicochemical principles involved in the use of surface-active agents in textile processing. The surface and bulk properties of the agents are studied and related to the over-all technical properties and uses.

CH 513-514 Physicochemical Methods (2-4)(2-4)6

Theory, applications, and limitations of important physical methods of analysis used in modern research. Methods include X-ray diffraction, ultraviolet and infrared spectroscopy, and microscopy (phase, polarization, electron). Special attention is given to methods for determining the size and shape of macromolecules.

CH 521-522 Physical Organic Chemistry (3-0)(3-0)6

A study of structure, bonding, and polarization as related to organic compounds. Electronegativity, hydrogen bonding, dielectric behavior, acids and bases, catalysis, and reaction mechanisms. Both catalysis and reaction mechanisms are correlated with the theory of absolute reaction rates.

CH 523-524 Organic Chemistry of (3-0)(3-0)6
Polymeric Species
 [CH 202, 332, 424]

The classification, mechanism of formation, structure, and properties in bulk of polymeric organic species.

CH 525-526 Chemistry of the Carbohydrates (3-0)(3-0)6
 [CH 202 and 332]

Starting with the chemistry of the simple sugars, this subject leads to a detailed study of the physical chemistry and the organic chemistry of the important polysaccharides, such as cellulose and starch, and of their industrially important derivatives.

CH 527 Metal-Organic Compounds (3-0)3

The chemistry of the important classes of metal-organic compounds including bis-arene derivatives. Includes in addition the organo-silicon, organo-boron, and organo-phosphorus classes.

CH 528 Stereochemistry (3-0)3

Concerns the fundamental concepts of optical and geometrical isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds.

CH 529 Heterocyclic Chemistry (3-0)3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

CH 531-532 Chemical Thermodynamics (3-0)(3-0)6

Classical and statistical principles of thermodynamics and their application to chemical problems. The description of system states and the development of criteria for determining the spontaneity of physical and chemical changes are emphasized.

CH 533 Statistical Mechanics for Chemists (3-0)3

Mathematical introduction to statistical mechanics and applications to chemical problems.

CH 534 Quantum Mechanics for Chemists (3-0)3

Mathematical introduction to quantum mechanics and applications to chemical problems.

CH 535-536 Advanced Topics in Physical Chemistry (3-0)(3-0)6

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 537 Chemical Kinetics (3-0)3

The theoretical and empirical treatment of chemical kinetic data of both organic and inorganic chemistry as well as the methods of obtaining these data. The determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanisms, complex reactions, and absolute rate theory.

CH 538 Rheology (2-0)2

The general principles of the deformation and flow of matter under stresses are studied qualitatively and quantitatively. Hookean and non-Hookean elasticity and Newtonian and non-Newtonian flow are related to the properties of materials, especially in the field of high polymers.

CH 541-542 Graduate Thesis Credits to be arranged

The graduate thesis is an independent investigation of a problem by the student in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is a required part of this subject.

CH 551 or 552 Textile Testing Problems (1-3)2
[CH 422]

Special problems relating to the design and evaluation of improved analytical or testing procedures.

CH 553-554 Evaluation of Finishing Agents Credits to be arranged

A laboratory study designed to teach the use of the various test methods and instruments in evaluating the effect of finishing treatments on the tactile and end-use properties of a fabric.

CH 555-556 Textile Chemistry Seminar (2-0)(2-0)4

A series of informal discussions of current problems in research and technology in the textile chemistry field. Special investigations of the literature will be utilized to serve as a source of seminar topics.

CH 559 Instrumental Methods in Textile Research (1-2)2

The use of instruments in textile chemical research. The lectures cover the general principles of instrumentation in the various fields considered. The laboratory exercises invoke the use of specific instruments and are designed to teach the student to make a proper choice of instrumental methods in common textile chemical problems.

CH 561-562 Polymer-Chemical Principles in the (3-0)(3-0)6
Technology of Organic Construction Materials

Application of polymer-chemical principles to the chemical technology of organic construction materials (orcons) such as textiles, plastics, paper, and leather. For example, it is shown how the principle of cross-linking is utilized to modify the performance properties of cotton and rayon (crease recovery), of wool (permanent pleating), rubber (vulcanization), textile finishes and plastics (curing), leather (tanning) and paper (wet strength), and how the principle of swelling is utilized to make these materials accessible to modifying agents as in finishing, dyeing, and plasticization.

CH 563-564 Special Topics in the Chemistry and (2-0)(2-0)4
Technology of Manufactured Fibers

[CH 355]

Important considerations in the areas of synthesis and structure of fiber-forming polymers, conversion of polymers into fiber forms, and fiber properties and applications.

ELECTRONICS

EL 201-202 Introductory Circuit Theory (4-0)(3-0)7

[PH 104 and MA 108; EL 205-206 and 207-208

taken concurrently]

An introduction to the study of the mathematical and physical aspects of electric circuits in which radiation in the form of electromagnetic waves does not play a major role. Resistive circuits, Kirchhoff's laws, Thevenin's theorem, reciprocity of simple circuits, sinusoidal steady-state behavior, vector diagrams, resonance, transients in alternating current circuits, loci of complex functions, polyphase systems, and an introductory discussion of simple non-linear circuits.

Text: Guillemin, *Introductory Circuit Theory*.

EL 203-204 Elementary Electricity and (0-3)(0-3)2
Magnetism Laboratory

[PH 104; EL 201-202 taken concurrently]

The purpose of this subject is to give the student a working knowledge of the use of common electrical devices and measuring equipment as well as practice in the preparation of circuit drawings, the writing of technical reports, and the analysis of the precision of measurements. Some attention is given to the practical techniques useful in the construction of electrical equipment and accessories.

Texts: Stout, *Basic Electrical Measurements*; Dunn and Barker, *Electrical Measurements Manual*.

[PH 104 and MA 108; MA 205 and 206 taken concurrently]

Text: Frank, *Introduction to Electricity and Optics*, 2nd edition.

Characteristics of electronic tubes; graphical solutions for circuits containing nonlinear elements; linear equivalent circuits; combinations of resistive, capacitive, and inductive elements; response of basic circuits to simple wave forms.

EL 305-306	Electronics Laboratory [EL 202, 204, 206, and 210]	(0-4)(0-4)4
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Text: Reed, Wagner and Corcoran, *Electrical Communications Experiments*.

[EL 202, 206; MA 206; EL 311-312 taken concurrently]

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magnetostrictive, electrothermal, and electromechanical devices; indicating and recording equipment, electrical computers, and fractional horsepower motors.

EL 309 Physical Basis for Electronic Engineering (3-0)3

[EL 206, MA 206]

Physical concepts and phenomena forming the basis for electronic engineering from the microscopic and macroscopic viewpoints. The electron, atoms and molecules, extranuclear atomic structure, nuclear structure, structure and behavior of metals and semiconductors, magnetic properties of matter, low-temperature phenomena, radioactivity, nuclear reactions, nuclear fission, applications of nuclear physics.

Texts: Martin, *Physical Basis for Electrical Engineering*; Van Name, *Modern Physics*.

EL 310 Electromagnetics (3-0)3

[EL 202, 206, 311; EL 312 taken concurrently; MA 206]

Electricity and magnetism are presented from the field theory point of view. Vector analysis is used throughout and Maxwell's equations are introduced early in the course. The topics covered include the static electric field in polarizable and conducting media, static magnetic fields of steady electric currents and ferromagnetic materials, time-changing electric and magnetic fields, magnetic induction, and boundary value problems associated with static fields.

Text: Kraus, *Electromagnetics*.

EL 311-312 Engineering Mathematics (4-0)(4-0)8

[MA 206]

Ordinary differential equations, Laplace transformation, numerical methods of solving differential equations, series solutions of differential equations, boundary value problems and orthogonal functions, vector analysis, partial differential equations, partial differential equations of mathematical physics, and complex variable theory.

Text: Hildebrand, *Advanced Calculus for Engineers*.

EL 321 Mechanics (3-0)3

[MA 206]

Vector formulation of kinematics; Newton's formulation; particle motion; motion of a group of particles; the Lagrange formulation; Hamilton's formulation. These expositions provide a development of vector calculus and an introduction to dyadics and to variational calculus.

Text: F. W. Constant, *Mechanics*.

- EL 322** **Thermodynamics** (3-0)3
[MA 206]
Systematic exposition of the first and second laws of thermodynamics; consequences of these principles in processes involving mechanical, electrical, magnetic, chemical, and thermal energy exchanges. An introduction to kinetic theory and statistical descriptions of gases and solids.
Text: Sears, *Thermodynamics, Kinetic Theory, and Statistical Mechanics*.
- EL 323** **Electronic Circuits** (3-0)3
[EL 210]
A continuation of EL 210. Amplifiers; oscillators; clamping, clipping, and trigger circuits; voltage-regulating circuits, multivibrators; and counting circuits.
Text: Corcoran and Price, *Electronics*
- EL 324** **Network Analysis** (3-0)3
[EL 202]
The formulation of general network equations and the development of various equivalent circuits and circuit theorems. The transient behavior of linear networks, characteristics of wave filters, circuits having continuously distributed constants, and other coupling networks.
Text: Van Valkenburg, *Network Analysis*.
- EL 401-402** **Servomechanisms** (3-0)(3-0)6
[EL 210 and 312]
A survey of industrial electronic control systems. Among the topics considered are: selsyns, amplidynes, regulators, servomechanisms, magnetic amplifiers, saturable reactors, inverters, high-current rectifiers, and high-voltage machines.
Texts: Brown and Campbell, *Principles of Servomechanisms*; Nixon, *Principles of Automatic Control*.
- EL 403-404** **Microwave Electronics** (3-0)(3-0)6
[EL 210, 310, and 312]
Practice in the analysis of electronic systems. Beginning with zero frequency circuits, a study is made of the modifications required to give proper behavior as the frequency is increased. Among the topics considered are: radio frequency circuits; television circuits; amplitude, frequency, and pulse modulation; elements of electromagnetic theory, antennas, waveguides, microwave generators and receivers.
Texts: Reich *et al.*, *Microwave Theory and Techniques*; Panofsky and Phillips, *Classical Electricity and Magnetism*.

EL 405-406 Communication Electronics (3-0)(3-0)6

[EL 210 and 323]

Theory and application of thermionic tubes and transistors in amplifiers, oscillators, modulators, and detectors operating class A and in the switching mode. Principles of television communication.

Text: Martin, *Electronic Circuits*.

EL 407-408 Pulse and Digital Circuits (3-0)(3-0)6

[EL 202, 210, and 323]

The response of linear networks, both active and passive, to the types of wave forms commonly encountered in pulse circuits. The effects of nonlinearities of tubes and transistors on wave form transmission. Wave form generating circuits and other fundamental building blocks are analyzed in detail. Basic circuits are considered when assembled into pulse and digital systems.

Text: Millman and Taub, *Pulse and Digital Circuits*.

EL 409-410 Electronic Projects Laboratory (0-4)(0-4)4

[EL 306]

In this subject the student is given the opportunity to develop, construct, study, modify, and test electronic components and systems. He is expected to carry out his investigations more or less independently. Original investigations are encouraged but not required. The careful preparation of technical reports on the experimental work is emphasized. Where practicable, the student is expected to write his reports using the style of either the *Journal of the Institute of Radio Engineers* or the *Review of Scientific Instruments*.

EL 411-412 Applied Electronics Laboratory (0-4)(0-4)4

[EL 306 and 310]

The purpose of this subject is to give the student an experimental familiarity with the nature, application, and performance of various electronic devices. Emphasis is given to the preparation of good technical reports.

Text: Terman and Petit, *Electronic Measurements*.

EL 429-430 Special Topics in Electronics (3-0)(3-0)6

An analytical consideration of special topics of importance in the field of electronics.

EL 433-434 Solid State Physical Electronics (3-0)(3-0)6

[EL 312]

A physical interpretation of the properties of materials in terms of their dielectric constant, magnetic permeability, electrical conductivity; dielectric, ferroelectric, piezoelectric materials; dia-

magnetic, paramagnetic, ferromagnetic, antiferromagnetic, ferrimagnetic materials; metals, semiconductors, insulators.

Electrical engineering devices whose performances are described in terms of the above properties.

Texts: Van der Ziel, *Solid State Physical Electronics*; A. J. Dekker, *Electrical Engineering Materials*; H. W. Katz, *Solid State Magnetic and Dielectric Devices*.

EL 435-436 Instrumentation (3-0)(3-0)6
[EL 210]

The basic principles of the science of measurement by electronics. Measurement of electrical quantities by electronic methods. The theory and methods of transducers for converting nonelectrical quantities into some electrical signal that may be measured by electronic methods.

EL 437 Introduction to Scientific Research (2-0)2

A survey of general principles, techniques, and guides for procedure which successful investigators in various fields of science have found helpful.

Text: Wilson, *An Introduction to Scientific Research*.

EL 440 Experimental Techniques (1-1)1

Experimental studies of heat treatment, hardenability, soft and hard soldering, glass blowing, applied vacuum techniques.

EL 501-502 Mathematical Methods (3-0)(3-0)6
for Engineers

Elements of function theory, differentiation, integration, space geometry, functions of a complex variable, residues and complex integration, and applications. Algebra of linear equations, vector and tensor analysis, orthonormal functions, integral equations, and variational methods.

Texts: Smith, *Mathematical Methods for Scientists and Engineers*; Page, *Physical Mathematics*.

EL 503-504 Introduction to Theoretical Physics (3-0)(3-0)6

The student is introduced to the analytical methods of theoretical physics. The major emphasis is placed on prequantum physics. The following topics are covered: the Lagrangian and Hamiltonian formulations of analytical mechanics; special relativity; elasticity and hydrodynamics, kinetic theory, thermodynamics, and statistical mechanics; electricity and magnetism from the field-variable point of view; Maxwell's equations; and atomic spectra and structure.

EL 505-506 Microwave Electronics (3-0)(3-0)6

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers, klystrons, magnetrons, and travelling wave tubes.

Texts: Reich *et al.*, *Microwave Theory and Techniques*;
 Reintjes and Coate, *Principles of Radar*; Panofsky and Phillips,
Classical Electricity and Magnetism.

EL 507-508 Intermediate Solid State Electronics (3-0)(3-0)6

An intensive study of selected topics in solid state electronics.

Texts: Shockley, *Electrons and Holes in Semiconductors*;
 Slater, *Quantum Theory of Matter*; Peierls, *Quantum Theory
 of Solids*.

EL 509-510	Transients in Electromechanical Systems	(3-0)(3-0)6
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Training in the formulation and solution of ordinary and partial differential equations which arise in the treatment of mechanical, acoustical, thermal, and electrical systems. Extensive use is made of modern operational mathematical techniques.

Text: Gardner and Barnes, *Transients in Linear Systems*.

EL 511-512 Dynamic Control Analysis (3-0)(3-0)6

The basic principles of electronic devices used for control and measurement in applied science and engineering.

Text: Truxal, *Automatic Feedback Control System Synthesis*.

EL 513-514 Electromagnetic Theory (3-0)(3-0)6

Maxwell's equations, stress and energy, the electrostatic field, the magnetostatic field, plane waves in isotropic media, cylindrical waves, spherical waves, radiation, and boundary value problems.

Text: Stratton, *Electromagnetic Theory*.

EL 515-516 Elementary Quantum Mechanics (3-0)(3-0)6

The postulational formulation of quantum mechanics. The basic theory is developed both in the operator and matrix formulations.

Texts: Schiff, *Quantum Mechanics*; Persico, *Fundamentals of Quantum Mechanics*.

EL 517-518 Solid State and Modern Physics (3-0)(3-0)6
for Engineers

Elements of electronics, special theory of relativity, atomic structure of matter, quantum mechanics, X-rays, molecular structure and molecular spectra, low-temperature phenomena, natural

and induced radioactivity, nuclear fission, cosmic rays and mesons, elements of crystal physics, specific heats, alloys of metals, elastic and plastic properties of solids, rupture and fatigue of solids, thermal diffusion, electron theory of metals and alloys, thermal and electrical properties of solids, energy levels in solids, cohesion in solids; magnetic, paramagnetic, and diamagnetic properties of solids; magnetic moments and resonance, transistor physics, semiconductors, and electron diffusion in metals.

Texts: Kittel, *Solid State Physics*; Slater, *Quantum Theory of Matter*; Peierls, *Quantum Theory of Solids*.

EL 529-530 **Network Synthesis** **(3-0)(3-0)6**

The formulation of the fundamentals of network theory. Establishing realizability conditions and synthesis techniques for various classes of networks and network functions. Methods are developed for realizing one or more networks whenever a function of the given class is prescribed.

Text: Balibanian, *Network Synthesis*.

EL 531-532 Seminar in Electronics (1-0)(1-0)2

Discussion by staff members and students of current journal publications and topics of current interest in electronic science, electronic engineering, and related areas of applied physics.

**EL 533-534 Special Problems in
Electronics**

The purpose of this subject is to give the student an opportunity for individual study, under the direction of a staff member, of topics in or related to electronic engineering.

EL 535-536 Graduate Research

Supervised research on some problem in electronic science, electronic engineering, or in certain areas of applied physics. The results of the research are to be embodied in a thesis acceptable to the departmental committee on graduate study.

ENGINEERING

EN 113 Engineering Graphics (0-3)1

Communication by graphic representation—orthographic and pictorial. Charts and graphs. Freehand and instrumental multi-view drawing, dimensioning, engineering geometry, isometric sketching.

EN 114 Engineering Graphics (0-3)1
[EN 113]

The use of graphics in the solution of problems. Visualization by descriptive geometry, and its exercise in vector geometry and intersections. Graphical calculus, nomography, and empirical equations.

EN 203 or 204 Mechanism (2-3)3

The basic principles of kinematics, in which the wide variety of process machinery available furnishes many specific examples. Frequent use of these mechanisms is made in the development of the subject. Some of the important topics covered are the following: rolling cylinders and cones, gearing, gear train design, epicyclic gear trains, flexible connectors including stepped pulley and cone design, cam design, linkages, and miscellaneous mechanisms.

EN 205 Mechanism (2-2)3

Similar to EN 203, except that in the laboratory time, particular study is made of textile mechanisms.

EN 211 or 212 Machine Tool Laboratory (1-2)1

The objective of this subject is to give the student an insight into the processing of metals through lectures and practical laboratory applications covering the basic machine tools such as the lathe, shaper, drill-press, and milling machine, and also the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, die-casting, welding, and forging.

EN 221 or 222 Applied Mechanics I (3-0)3
[MA 108, PH 103]

The fundamentals of statics including such topics as force systems, laws of equilibrium, centers of gravity, moments of inertia, and analysis of stresses in framed structures.

EN 225 or 226 Applied Mechanics II (3-0)3

[EN 221; MA 206 taken concurrently]

The principles of rectilinear and curvilinear translation, rotation, and plane motion; Newton's laws, D'Alembert's principle. Work and energy, impulse and momentum, mechanical vibrations.

EN 232 Engineering Materials (3-2)4

[PH 103]

The manufacture, properties, and uses of important ferrous and nonferrous metals; hot and cold processing, alloying, heat treatment; also the properties and use of nonmetallic engineering materials such as timber, cement, concrete, rubber, plastic, and mechanical fabrics.

EN 234 Plastics Mold Design and Construction (1-2)1

[EN 211 or 212]

The purpose of this course is to acquaint plastics engineering students with the basic principles of mold design and construction in addition to machining and finishing operations of plastics. Sufficient laboratory time is provided to allow for the design and construction of simple molds.

EN 303 Electrical Circuits (3-2)3

[MA 206, PH 205]

Principles of electric circuit analysis by the use of the mathematical complex-plane and operational methods: Ohm's and Kirchhoff's laws, network theorems, Fourier analysis, and the Laplace transformation. Transient and steady-state behavior, resonance, magnetic coupling; the concept of equivalent circuits, and examples of nonlinear circuits.

EN 305 Thermodynamics (3-0)3

[MA 205, PH 104]

The thermodynamic system, the first law of thermodynamics, internal energy. Open and closed systems, steady flow, reversibility. The second law of thermodynamics, entropy, availability. The pure substance, the perfect gas; mixtures of gases and vapors.

EN 307 Surveying and Structures (3-3)4

[EN 221]

The fundamental principles of plane surveying, topographic surveying and mapping; principles of structural engineering; algebraic and graphical analysis of forces; calculation of allowable floor loads, stresses in beams; and allowable loads on columns.

EN 308 Structures (3-0)3

[EN 307]

Rigid frames analysis, wind stresses, stresses in riveted trusses, reinforced concrete structures, footings, foundations.

EN 309 Metals Processing (2-2)3

[EN 211 or 212]

Modern methods of manufacture including casting, forging, metal cutting and turning, spinning, welding. Testing for hardness and tensile strength; shrink fits, soldered and welded joints. Survey of current technical literature and special topic assignments.

EN 311 Heat and Power (2-2)3

[PH 205]

Similar to EN 403 but briefer and designed for those not majoring in engineering.

EN 313 or 314 Advanced Mechanism (2-2)3

[EN 203]

The graphical and mathematical analyses of advanced mechanisms found in various machines. The forces in, and velocities of, the various members of the mechanism are determined from actual data taken from the machines by the student. The subject is terminated with a problem in the design of a mechanism.

EN 316 Applied Thermodynamics (3-3)4

[EN 305]

Applications of the basic principles of thermodynamics, properties of steam and its utilization, and the combustion of fuels. A treatment of steam-generating units, turbines, and pumps.

EN 317 or 318 Applied Mechanics III (3-0)3

[EN 221, MA 206]

Stress, strain, Hooke's law. Shearing stress, riveted and welded connections. Combined stresses, Mohr's circle. Shearing force and bending moment. Beam stresses, normal bending, deflections. Simple torsion, column theory.

EN 319 or 320 Mechanical Vibrations (3-0)3

[EN 226]

Kinematics of vibration; systems with one degree of freedom, two degrees of freedom, many degrees of freedom; multicylinder engines, rotating machinery, self-excited vibrations; systems with nonlinear characteristics.

EN 325 or 326 Applied Mechanics (3-0)3

[MA 108, PH 103]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

EN 328 Strength of Materials (3-0)3

[EN 325]

Principles of the strength of materials with special emphasis on their applications to plastics. Includes such topics as bending and shearing stresses, torsion, compound beams and columns, reversals of stress, impact, vibrations, stress analysis by strain gage methods, concepts of creep and relaxation.

EN 331 or 332 Strength of Materials (3-0)3

[EN 221 or 325]

This subject covers such topics as stress fundamentals, strain bending moment and deflection, beam design, torsion, columns, combined stresses, reversals of stress, and impact.

EN 335 or 336 Physical Metallurgy (3-0)3

[MA 206, PH 206]

Atomic structure, crystal structure and imperfections, phases and transformations, phase diagrams, electrical and magnetic properties related to structure, thermal and optical properties, elasticity and plasticity in metals, diffusion, recovery, recrystallization, grain growth, hardening, and heat treatment.

EN 342 Principles of Electrical Engineering (3-2)4

[PH 351]

The greater part of the subject is devoted to direct-current generators and motors with a study of their construction and characteristics. Three-phase circuits and alternators are also considered. The accompanying laboratory work illustrates the various methods of measuring polyphase power and of determining the characteristics of direct-current generators and motors.

EN 344 Electrical Machinery (3-2)4

[PH 351 or 352 taken concurrently]

A condensation of EN 342 and EN 401.

EN 351 or 352 Statistical Methods (3-0)3

[MA 205]

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

EN 401 Principles of Electrical Engineering (3-2)4

[EN 342]

Alternator regulation, parallel operation, single-phase and three-phase transformers, induction motors and their applications, starting devices for motors, synchronous motors, and correction of power factor.

EN 402 Electrical Control Systems (3-3)4

[EN 401]

The operation of simple servomechanisms, potentiometers, synchros and related error detectors, double-speed synchronizing networks, demodulators and modulators, electronic amplifiers, servomotors, magnetic and rotating amplifiers, design of servomechanisms, tests of servomechanisms.

EN 403 Principles of Heat Engineering (3-2)4

[MA 205, PH 104]

The basic principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and the combustion of fuels. A brief treatment of steam engines, turbines, and pumps. Special consideration is given to the use of steam in manufacturing processes.

EN 404 Heat Transfer (3-0)3

[MA 205, PH 104]

Modes of heat transfer; conduction, radiation, forced and free convection. Dimensional analysis. Heat transfer to boiling liquids and condensing vapors. Over-all transfer of heat. Finned surfaces and heat exchangers. Transient conduction.

EN 405 Electronic Controls and Power Circuits (3-2)4

[PH 205]

Power requirements in single-phase and three-phase power circuits; operating characteristics of various types of direct-current and alternating-current motors and their manual and automatic controls; industrial electronics including photoelectric relays, time delay relays, motor control, and side register control as applied in the plastics industry.

EN 406 Fluid Mechanics (3-2)4

[MA 205, PH 205]

Properties of fluids; statics of fluids; flotation; relative equilibrium; dynamics of fluids, Bernoulli's theorem, measurement of velocity and pressure; cavitation; flow of viscous fluids; Reynolds' number; flow in pipes; flow with free surface; critical depth; weirs;

orifices and nozzles; impulse and momentum in fluids; resistance of immersed and floating bodies. Froude's number, boundary layer; dynamics of compressible fluids; Mach's number; dynamical similitude and Pi theorem.

EN 407 or 408 Fluid Mechanics (3-0)3

[MA 205, PH 205]

Similar to EN 406 but without laboratory work.

EN 411 or 412 Advanced Heat Engineering (2-3)3

[EN 316]

Elements of the design of power plants and heating systems, internal combustion engines, and related subjects.

EN 419 or 420 Industrial Instrumentation (2-3)3

[PH 205]

Similar to EN 422 with the addition of three hours of laboratory per week.

EN 422 Industrial Instrumentation (2-0)2

[PH 205]

Modern methods of measurement and control of the more common process variables such as temperature, pressure, liquid level, and fluid flow; response characteristics of mechanical, electric and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; closed-loop control systems; process characteristics and their effects upon the selection of the correct mode of control.

EN 424 Instrumentation for Textiles (2-2)3

[PH 352]

A study of indicating and recording instruments used to measure such common textile process variables as pressure, temperature, humidity, liquid level, fluid flow, etc. Response characteristics of mechanical, electrical, and electronic systems, and process characteristics and their effects upon the selection of the correct mode of control.

EN 427-428 Machine Design (2-3)(2-3)6

[EN 317]

The application of engineering principles to the design of machine elements including working stresses, shafting, springs, screws, belts, clutches, brakes, lubrication, bearings, gearing, press and shrink fits, miscellaneous machine elements, and optimum design considerations.

EN 433 Manufacturing Tools and Methods (3-0)3
Not offered in 1959-60

Designed to familiarize students with manufacturing methods and machines in general industrial work. Plant layout and planning; machine tool performance; power transmission and control; product evaluation and quality control.

EN 441 or 442 Air Conditioning (2-2)2
[PH 205]

The fundamental principles of heating, ventilating, and refrigeration. The laboratory consists of design problems in the air conditioning of industrial buildings.

EN 451-452 Electromechanical Engineering (3-3)(3-3)8
[EN 303 and 344]

A study of methods of measurement and control in electromechanical systems. Servomechanisms, analog and digital computers, switching circuits and motor controls. The characteristics of various types of electromechanical transducers and their associated circuitry as employed in the measurement of such quantities as acceleration, velocity, displacement, stress, strain, thickness, mass and weight, and frequency and intensity of sound; also in inspection devices and in such applications as the generation and use of ultrasonic waves.

EN 501 or 502 Statistical Quality Control (3-0)3
[EN 351 or 352]

A study of the various types of control charts for maintaining the quality of manufactured products and the several types of sampling plans for the reduced inspection of manufactured products and of raw materials. Applications of the foregoing statistical techniques to various industries are considered.

EN 505 or 506 Methods of Experimental (2-3)3
Stress Analysis
[EN 317, MA 205, PH 205]

An introduction to some of the experimental techniques used in stress analysis. Photoelasticity, electrical strain gages, brittle coating, and mechanical gages are considered in relation to the analysis of both static and dynamic stresses. Special attention is given to the application of these techniques in the study of industrial structures and machinery.

EN 509 or 510 Advanced Statistical Methods (3-0)3
[EN 351 or 352]

A continuation of EN 351 or 352 with particular study of the more advanced statistical techniques as applied to the design of industrial experiments and to the analysis and interpretation of the resulting data.

EN 591 and 592	Graduate Thesis	Credits to be arranged
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Each candidate for a graduate degree in engineering is required to submit a thesis which shows ability and originality in the solution of a research project. May be repeated for credit.

EN 593-594	Graduate Seminar	(1-0)(1-0)2
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Required of all graduate students in engineering.

GENERAL STUDIES

GS 101-102	Elements of Political and Economic Geography	(2-0)(2-0)4
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A survey of the factors influencing the contemporary relations of nations. Population, industry, resources, climate, and political structure are studied through readings, discussion, and class lectures.

GS 111	English Composition	(3-0)3
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Training in the basic principles of clear and correct composition. Concentration on paragraph construction and development leading to effective expository writing. Introduction to the elementary research techniques of outlining, note taking, footnoting, compiling bibliographies, and using the library. Analysis and discussion of the composition and content of collateral reading. Regularly assigned written exercises and individual conferences.

GS 112	English Composition	(3-0)3
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Training in the composition of extended written exercises. Emphasis on analysis and evaluation. A guided research project. Critical analysis and discussion of collateral reading in the sciences and humanities. Regular individual conferences.

GS 121 or 122	Perspective Drawing	(1-1)1
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A mechanical method of representing objects of three dimensions, showing correct proportions as they appear to the eye.

GS 131 or 132	Freehand Drawing	(0-3)1
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Freehand drawing of objects of different textures. Visual training and graphic expression to build a drawing vocabulary which will aid in advanced drawing subjects.

GS 201	Principles of Economics I	(3-0)3
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The foundations and nature of economic principles. National income, money and banking, and a brief survey of economic history.

GS 202 Principles of Economics II (3-0)3

[GS 201]

Price and production theories, the distribution of income, and comparative economic systems.

GS 209 or 210 Speech (2-0)2

[GS 112]

The aim of this subject is to achieve effective delivery of various types of speech. All kinds of delivery are studied and analyzed.

GS 211 or 212 Business English (2-0)2

[GS 112]

Analysis and practice in letter writing and a study of the basic forms of technical exposition, forming a background for report writing in advanced courses and in industrial activity.

GS 213 Technical and Scientific Writing (3-0)3

Thorough grounding in the special demands of technical and scientific exposition, including reports, technical and business correspondence, and research papers, supplemented by readings in technical and scientific fields. Practice in oral communication in connection with the presentation of abstracts, summaries, and reports based on readings and on problems coordinated with the written requirements of other departments.

GS 214 Communication of Ideas (3-0)3

Study and interpretation of assigned readings in the several forms of nontechnical writing, such as the novel, short story, drama, essay, and poetry, with the purpose of familiarizing the student with the methods by which thought is communicated. Skill in presenting ideas is developed through written assignments, including essays or reports of an analytical or critical nature, through oral expression by panels and committees, and through individual oral presentation of assigned subjects.

GS 222 Appreciation of Literature (3-0)3

The principles of literary appreciation and criticism. An analysis of prose and poetical selections, with directed investigation of the various literary appeals—the intellectual, the sensory, the emotional, the aesthetic, the imaginative, and the philosophical.

GS 223-224 The United States since 1865 (2-0)(2-0)4

A survey of the advancement of the American people from the Reconstruction Era to the present.

- GS 226 World History since 1900 (3-0)3**
 Particular attention is paid to the years 1919-1939 and such topics as the rise of new states; the origin and development of new concepts of nationalism, racism, and other phenomena; the alignment of world powers for World War II; and the role of the United States in mid-twentieth-century reconstruction.
- GS 233 Comparative Literature (3-0)3**
 A consideration of at least six classics of western civilization as keys to the development of literary types. An attempt to deduce standards of critical judgment. Class discussions and critical papers.
- GS 234 Shakespeare (3-0)3**
 Shakespeare's chief tragedies, comedies, and chronicles. Lectures and discussions on Shakespeare and the nature of man. Critical papers.
- GS 261-262 Technical German (3-0)(3-0)6**
 The basic elements of German, leading to the development of reading ability in scientific German.
- GS 263-264 Technical French (3-0)(3-0)6**
 The basic elements of French, leading to the development of reading ability in scientific French.
- GS 265-266 Elementary Russian (3-0)(3-0)6**
 An introduction to the study of the Russian language to develop basic grammar and reading knowledge.
- GS 301 Economic Development of the United States (3-0)3**
 A brief review of the background of the present economic system and an intensive study of the influence of science and technology upon our economic development. The central theme is the dominant role of the science and technology of our time in present-day American life.
- GS 302 Modern Labor Problems (3-0)3**
 The backgrounds of present-day labor organizations and modern labor law with particular emphasis upon current labor problems in the United States. The major objective of the semester is to familiarize upperclass students with the procedures and techniques of collective bargaining with special attention to the formulation and administration of various types of labor contracts.
- GS 303 Psychology (3-0)3**
 The place of psychology in the life of the individual and society. A survey of the psychological basis of behavior and attitude as related to personal, industrial, and community experiences.

GS 305 **Sociology** **(3-0)3**

A consideration of the basic principles of sociology, including the development of man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

GS 307 Principles of Finance and Banking (3-0)3
[GS 202]

[GS 202]

The monetary and banking system in the United States. The financial organization of business. The role of the Federal Reserve System and the Treasury in terms of monetary and fiscal policy.

GS 311 **Economic Statistics** **(3-0)3**

Basic concepts of the statistical method with special emphasis on those approaches of most interest to the student of management. Topics covered include measures of central tendency, graphic methods, dispersion, skewness, sampling, normal curve, index numbers correlation, time series, secular trend, seasonal variation, business cycle, and statistical forecasting.

GS 314 **Philosophy of Science** **(3-0)3**

This subject analyzes the methods and techniques of inductive and deductive science. Elementary logic is studied and applied to the necessary structure of scientific systems. The great concepts and generalizations which have marked the history of science are reviewed and analyzed, as well as the interrelation of science and general philosophy.

GS 321 or 322	Industrial Marketing	(3-0)3
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Marketing principles as they affect the engineer entering the manufacturing enterprise. Emphasis on industrial aspects of marketing including such factors as procurement (make or buy), pricing, and distribution.

GS 341 Accounting I (3-0)3

The significance of accounting, its underlying theories, and the organization and use of modern accounting records. The preparation of the balance sheet and profit and loss statement. Theory of debits and credits as applied to journalizing and usage of various ledgers and journals. Comparison of corporate, partnership, and proprietorship forms of organization from the accounting standpoint.

GS 342 Accounting II (3-0)3
[GS 341]

[GS 341]

A continuation of GS 341 with emphasis on partnership and corporate accounting. Tax accounting; installment and branch

accounting; interpretation and analysis of formal financial statements; preparation of accounting reports. General study of cost accounting principles and applications.

GS 344 Cost Accounting (3-0)3
[GS 341]

Cost finding for manufactured goods. The necessity and principles of material control and accounting; direct labor accounting, overhead accounting, and distribution costing. Job order, process, and standard cost accounting systems are utilized.

GS 361-362 Advanced Technical German (3-0)(3-0)6
[GS 262 or equivalent]

GS 361 may be taken without continuing GS 362.

This subject is designed to expand the student's elementary understanding of the language, increase vocabulary, and develop reading aptitudes in special fields of interest selected by the student.

GS 371 or 372 American Civilization to 1865 (3-0)3

The beginnings of a national consciousness viewed from the aspects of the cultural, economic, and social evolution of the American people. The way of life of a growing democracy—its methods of livelihood, its art, its religious activities, its industries, its literature.

GS 401 or 402 Industrial Relations Seminar (2-0)2
[Permission of instructor]

This subject gives a small, selected group opportunities to meet with the instructor and occasional visitors in discussion of current problems in industrial relations. Case material and hypothetical problems in modern labor management provide the basis for group study.

GS 404 Government and Business (3-0)3

An examination of the direct controls imposed by federal, state, and local governments upon business activity. Emphasis is placed upon the economic interpretation of the various government statutes, and important court decisions affecting business are studied.

GS 411 or 412 Industrial Management: (3-0)3
Principles and Problems

Backgrounds of modern industry, organization of the industrial enterprise, the operation of modern industry, and coordination of the productive processes. Among the topics covered are risks, forecasting, financing, product development, plant layout,

production controls, personnel management, time and motion studies, job evaluation, and wage and salary administration. The text material is supplemented with current readings and case material.

GS 421 Industrial Procurement (3-0)3

[GS 321 or 322]

Not offered in 1959-60

Purchasing procedure, quality control, inventory control, source selection, forward buying and speculation, and salvage operations as applied to the manufacturing enterprise.

GS 441 International Trade Theory (3-0)3

[GS 202]

Trade theory from Ricardo through modern concepts. International payments, national exchange and trade control, and policy determination.

GS 442 Export Sales Management (3-0)3

[GS 321 or 322]

World marketing from the viewpoint of the American producer. Management of foreign operations and location of production abroad.

GS 443 Industrial Advertising (3-0)3

[GS 321 or 322]

The principles of advertising and their application to the industrial field. The use of trade papers, direct mail, and other forms of advertising media.

GS 444 Sales Management (3-0)3

[GS 321 or 322]

Sales management in its broader aspects. Sales organization, management of a sales force, compensation of salesmen, and the selection, training, and supervision of salesmen. Market research, product packaging and development, and distribution policies are also considered.

GS 459 International Relations (3-0)3

The nature of the state system involving the state itself, nationalism, sovereignty, and national power; the various tools and instruments which states have available for use in the promotion of their national interest; and the controls present to restrain states and make possible international order.

GS 461 Personnel Management (3-0)3

A comprehensive study of modern labor management techniques in the recruiting, selection, training, and placement of members of the work force. Personnel administration agencies and procedures, with special attention to such matters as employee health and safety, welfare and recreation programs, wage and salary administration, training and education, and management relations with labor organizations.

GS 463 or 464 Business Law (3-0)3

The principles of commercial law including contracts, agency, sales, partnerships, corporation, negotiable instruments, bailments and carriers, insurance, personal property, real property, suretyship and guarantee, and bankruptcy.

GS 465 or 466 Management Problems Research (3-0)3

[Permission of instructor]

Normally restricted to seniors and graduate students.

Under faculty guidance, a student studies a topic in the field of finance, marketing, or production. The findings are presented in formal thesis form. These theses are retained by the Department for permanent reference.

GS 468 Investment Fundamentals (3-0)3
[GS 307]

The nature of different types of corporate securities from the viewpoint of the individual investor. Emphasis is placed upon the significance of various analytical techniques involved in appraising the intrinsic merits of industrial securities. Investment policy problems of portfolio construction are considered.

GS 470 Comparative Modern Governments (3-0)3

Twentieth-century political thought and the structure and functions of government agencies in democratic and totalitarian political systems. Emphasis is given to new concepts of government authority and responsibility and to changing patterns of international relations.

GS 472 American Foreign Policy, 1774 to the Present (3-0)3

The development of U. S. foreign policy from the beginnings of the Republic to the present. Particular attention is given to the influences of two world wars and their aftermaths upon American participation in global politics.

GS 473 The Modern American Novel (3-0)3

A consideration of outstanding American novelists from 1920 to the present. Selected works of Faulkner, Fitzgerald, Hemingway, Wolfe, and others are read and discussed.

GS 474 Modern Drama (3-0)3

An analysis of major forces in the theatre from the time of Ibsen to the present. Selected representative plays of American and European dramatists are read and discussed.

GS 475 Contemporary English Literature (3-0)3

A survey of the major English writers of this century with representative readings from novelists such as Hardy, Huxley, Conrad, Orwell, and Waugh; from such poets as Brooke, Owen, Eliot, Spender, Thomas, and Auden; from Maugham, Galsworthy, Shaw, and other dramatists; and from representative nonfiction prose writers—Russell, Toynbee, and Churchill. Supplementary readings in literary, political, and social backgrounds of the period are required.

LEATHER

LE 202 Applied Leather Analysis (1-4)2
[CH 102]

A subject designed to acquaint the student with the accepted methods of analysis of the American Leather Chemists Association and other supplementary procedures.

LE 301-302 Leather Technology (3-6)(3-6)10

Introduction to the technology of leather manufacture. The first semester is devoted to examining government regulations in imported hides and skins, studying the purchasing of hides and skins, and classifying various hide damages. This is followed by work on the handling of raw stock at the tannery, unhairing, bating, and hide classification. The second semester is concerned primarily with the study of vegetable tanning, chrome tanning, and various other types of tanning. In the work throughout the year the material covered in lectures is supplemented by laboratory studies on a small scale.

LE 303 Leather Histology (2-4)4
[CH 201-202]

A study of the structures of animal skin and of the changes which they undergo in the leather-making process. Because the basically extracellular nature of skin demands it, considerable time is devoted to the nature and function of the fundamental protein constituents.

LE 304**Leather Microbiology****(2-4)4**

[CH 202 or permission of instructor]

An introduction to the study of microbiology, with special emphasis placed upon the microorganisms which may be encountered on skins or in the tannery.

LE 401-402**Leather Technology****(3-6)(3-6)10**

[LE 302]

A continuation of the study of the technology of leather manufacture covering the various currying treatments applied to rough leather, such as fatliquoring, stuffing, dyeing and the various mechanical operations of setting, stretching, etc. It is intended to show how widely the physical properties of leather may be varied and controlled by the proper application and selection of these numerous operations and treatments.

LE 404**Properties of Leather****(2-3)3**

[EN 351 and LE 401]

A practical and theoretical study of the characteristics of leather in relation to the end use. Studies are made on measuring and classifying the effect of changes in manufacturing procedure, both chemical and physical. Leather, because it is a natural product, varies considerably within the same hide. Thus, the nature of this variation is very important and the study of any changes affecting it is, in turn, important.

LE 405**Leather Seminar****(1-0)1**

A seminar on recent advances in leather research. Written and oral reports are required, and time is devoted to techniques of proper presentation of these reports.

LE 406**Leather Seminar****(1-0)1**

A continuation of LE 405.

LE 411-412**Leather Problems****(1-6)(1-6)6**

[LE 302]

This subject is designed primarily to enable the student to put into practical application the various scientific principles of physics, chemistry, mathematics, economics, etc. on problems of an industrial nature. This may encompass anything from the design and layout of any of a number of special leather plants to the suggested solution of practical problems which arise in the operation of a modern leather business.

LE 501-502 Tanning Mechanism (3-0)3

A study of the principal tanning processes in the light of modern concepts of chemistry. A critical appraisal of the information documented in the literature in comparison with actual experience taken from the technological aspects of tanning.

LE 503-504 Microbiological Studies of Leather (3-5)5

The general principles and laboratory techniques of microbiology are considered. Special emphasis is placed upon the bacterial and mycological problems arising in the leather industry.

LE 505-506 Graduate Seminar (1-0)1

Round-table discussion among staff members and graduate students on certain phases of thesis work, published scientific reports, and recent progress in leather technology.

LE 507-508 Graduate Thesis Credits to be arranged

LE 509-510 Microbiology of Skins (3-5)(3-5)10

A study of microorganisms found in and on skins, their identification, classification, and enumeration. In addition consideration is given to the biochemical activities of these organisms and their importance in the handling of skin and the making of leather.

MATHEMATICS

MA 107 Introduction to Mathematical Analysis (4-0)4

This subject is intended to provide a firm foundation for the student's subsequent studies in the nature and the use of mathematical functions. Topics considered include functions and graphs, logarithmic and exponential functions, the differentiation and integration of simple functions together with applications involving related rates, differentials, maxima and minima, areas, volumes, lengths of curves, pressure, and work.

MA 108 Calculus and Analytic Geometry (5-0)5

[MA 107]

The conic sections; equations of motion; mean value theorem; the differentiation and integration of trigonometric, inverse trigonometric, logarithmic, and exponential functions; centroid and center of mass; the theorems of Pappus; moment of inertia; polar coor-

dinates; determinants; synthetic division; properties of roots of higher-degree functions; the translation and rotation of curves; hyperbolic and inverse hyperbolic functions; and further applications to chemistry and physics.

MA 205 Calculus and Analytic Geometry (4-0)4

[MA 108]

Integration by parts, integration by partial fractions, other integral forms, parametric equations, differentiation of vectors, tangential and normal vectors, elementary vector analysis, solid analytic geometry, partial differentiation, multiple integrals, infinite series, and complex functions.

MA 206 Differential Equations (3-0)3

[MA 205]

The solution of ordinary differential equations and of partial differential equations of the first order and first degree and of forms in certain other orders and other degrees that lend themselves readily to solution. Practical applications to chemistry and engineering.

MA 301-302 Advanced Calculus (3-0)(3-0)6

[MA 206]

A further study of differential equations. The Laplace transformation, numerical methods for solving differential equations, series solutions of differential equations, boundary value problems and orthogonal functions, vector analysis, partial differential equations arising in mathematical physics, and problems suitable for the use of a complex variable. Extensive applications.

MA 306 Theory of Equations (3-0)3

[MA 108]

Mathematical induction, complex numbers, integral and rational roots, solution by radicals, impossibility of certain geometrical constructions, number of real roots, isolation of a root, determinants, and approximate methods of solution.

MA 403-404 Modern Mathematical Methods (3-0)(3-0)6

[MA 302]

An introductory course in modern mathematical techniques. Set theory, sets and functions, cardinal numbers. Linear algebra, vector spaces, and matrix theory. Elements of probability theory, Markov chains and statistics.

MA 406 Mathematical Statistics (3-0)3

[EN 351, MA 205]

Measurements of dispersion, theoretical frequency distributions, tests of goodness of fit and independence, partial and multiple correlations; permutations, combinations, and probability; game theory.

MA 513 or 514 Tensors and Matrices (3-0)3

The algebra of vectors and matrices. Special matrices and quadratic forms. The tensor concept, covariant and contravariant tensors, the metric tensor and other associated tensors. Covariant differentiation, Riemannian and Euclidean spaces with applications to geometry.

MA 515 Mathematics of Engineering Systems (3-0)3

The solution of linear differential equations by classical methods and by modern methods, and the solution of nonlinear differential equations by various methods.

MA 533 or 534 Matrix Theory (3-0)3

Linear vector spaces. The algebra of vectors and matrices. Linear transformations, special matrices and quadratic forms. Characteristic roots and reduction to diagonal form. Applications to physics and quantum mechanics.

MA 537-538 Group Theory (3-0)(3-0)6

Elements of set theory. Mappings, isomorphisms, and cardinality. Semigroups and groups. The theory of finite groups. General representation theory. Applications of group theory to quantum mechanics.

MA 541 or 542 Fourier Series and (3-0)3
Boundary Values

[MA 206]

The Fourier series as a tool of analysis. Dirichlet's Theorem. Orthogonal functions. Convergence tests. The Fourier integral. Cylindrical and spherical harmonics. Boundary value problems.

MA 545 or 546 Partial Differential Equations (3-0)3

The Cauchy problem. Classification of equations. Special emphasis on hyperbolic, elliptic, and parabolic differential equations. Existence and uniqueness theorems; dependence of solutions on boundary conditions.

MA 553 or 554 Tensor Analysis (3-0)3

The tensor concept. Covariant and contravariant tensors. The metric tensor, associated tensors, and covariant differentiation. Euclidean and Riemannian manifolds. Applications to geometry and analytical mechanics.

MA 573 or 574 Functions of a Complex (3-0)3
Variable

Complex numbers, point sets, and elementary functions. An introduction to regular analytic functions. Classification of singularities. Conformal mapping and applications.

MA 591 or 592 Graduate Thesis Credits to be
arranged

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

PAPER

PA 301 Pulp Technology (3-0)3
[CH 211]

Lectures and problems concerning the technology of pulp manufacture by the ground-wood, sulfite, alkaline and semi-chemical processes. Bleaching methods are studied.

PA 302 Paper Technology (3-0)3
[CH 211]

Lectures and problems concerning the technology of paper manufacture. Material covered includes stock preparation, filling and loading, sizing, coloring, special additives, paper machine operation, and finishing.

PA 303 Pulp Laboratory (2-6)4
[CH 211]

This as well as subsequent laboratory work is designed with a research-type approach to develop the student's ability to plan and analyze the experimental work and to reach logical conclusions from the results. Studies are made of the principal wood, rag and wastepaper pulps. The work includes wood and pulp microscopy, bleaching, and evaluations of pulps for their papermaking value by physical and chemical testing methods. Detailed written and oral reports are required.

PA 503-504**Plant Design****(4-0)(4-0)8**

[CH 333, CH 442, PA 302]

Design of a paper, boardmaking, or converting process and plant. Included are the material and labor requirements, equipment selection (or design where commercial equipment is not available), the plant layout, and complete economic analysis. One detailed, formal written report including blueprints of equipment and plant layout is required. Principal reference texts: Vilbrandt, *Chemical Engineering Plant Design*; Schweyer, *Process Engineering Economics*.

PA 505-506**Advanced Papermaking and
Paper Converting****(2-6)(2-6)8**

Nonfibrous raw materials used in the specialty papermaking and paper-converting fields with emphasis on recent developments and new uses. These materials are studied with regard to their chemical and physical properties, the technology of application, and processed sheet properties.

PA 507-508**Graduate Seminar****(1-0)(1-0)0**

Every graduate student is required to attend a weekly seminar with the staff. Student thesis progress, articles in recent literature, and unpublished recent developments in the field are discussed.

PHYSICS

PH 103**Physics****(4-1)4**

[MA 107 taken concurrently]

The principles of mechanics, including composition and resolution of vectors, statics, moments, rectilinear motion, Newton's second law, motion of a projectile, work and energy, impulse and momentum, circular motion, rotational kinematics and dynamics, elasticity, harmonic motion, hydrostatics, hydrodynamics, and viscosity.

PH 104**Physics****(4-1)4**

[MA 108 taken concurrently, PH 103]

Heat, sound, and the basic principles of electricity and magnetism, including the following topics: thermometry, quantity of heat, change of state, heat transfer, thermal properties of matter, the first and second laws of thermodynamics, wave motion, vibrating systems, acoustical phenomena, Coulomb's law, potential, d.c. circuits, the magnetic field, galvanometers, ammeters, voltmeters, watt-

PH 351 or 352 Electronic Circuits Gen. Eng. (3-2)4
(Former PH 321 or 322) Others (3-1)3

[PH 205]

Characteristics of electron tubes and semiconductors, and their circuits for the basic functions of rectification, amplification, oscillation, and modulation. Fourier analysis, circuit analysis by the graphical technique for nonlinear characteristics and by the linear equivalent circuit, and the response of basic circuits to simple wave forms. Laboratory work for practice in the setting up and analyzing of fundamental circuits, emphasizing the principles and use of basic electronic instruments.

PH 353 or 354 Electromagnetic Theory (3-0)3

[MA 301 or 302 taken concurrently, PH 251]

Theory of electromagnetic fields. Polarization fields, solutions of Laplace's equation, magnetic potentials, Maxwell's equations and their application to guides and cavities. Fresnel's equations. The Hertzian oscillator.

PH 355 or 356 Physical Electronics (3-3)4

[MA 206, PH 206]

Motion of charged particles in electric and magnetic fields, and examples of electron optics in instruments; statistical theory of metals: behavior of electrons in solids; the phenomena of thermionic, photoelectric, and high field emission from metals; and boundary layer contact potential. Characteristics of thermionic cathodes. Diode and multielement vacuum tube characteristics and circuits. Noise; elements of radioastronomy. Kinetic theory of gases: fundamental processes in gases; electrical discharges in gases; phenomena of plasma and the effects of ionized regions on radiation; the operational characteristics of popular gas tubes.

PH 357 or 358 Electrical Measurements (2-3)3

[MA 206, PH 206]

Precision of measurements, zero frequency and low frequency measurements by both deflection and null methods, amplifiers and tube electrometers, oscillographs, measurements at high frequencies, magnetic measurements, electrical measurements in mechanics, heat, acoustics, optics, and nuclear science.

PH 361 or 362 Intermediate Nuclear Physics (3-0)3

[MA 206, PH 206]

The elements of wave mechanics. The deuteron, n-p scattering theory. Alpha decay theory and radioactivity. Gamma and beta radiation. Range-energy relations. Particle detectors. Neutron diffraction. Nuclear structure, nuclear reactions.

PH 411-412 Quantum Mechanics (3-0)(3-0)6

[MA 403-404 taken concurrently, PH 311 or 312]

Historical introduction. The uncertainty principle, Schrodinger's equation, and the wave mechanics of a particle. The general theory of quantum mechanics, matrix methods, and perturbation theory. Relativistic wave equations with emphasis on the Dirac theory of the electron.

PH 421 Physical Thermodynamics (3-0)3

[MA 302, PH 222]

Not offered in 1959-60

PH 431 or 432 Theory of Vibrations and Sound (3-0)3

[MA 301, PH 312]

Free, damped, and forced oscillations; forcing by pulses; coupled oscillations; the flexible string; end conditions; perturbations; the vibration of bars, membranes, and plates; sound waves; acoustic impedance; the radiation and scattering of sound; normal modes; and reverberation. Applications are stressed.

PH 461-462 Nuclear Physics (3-0)(3-0)6

[PH 361 or 362; MA 403 and PH 411-412 taken concurrently]

The general properties of the nucleus. The nuclear radius, nuclear moments and the systematics of stable nuclei. Nuclear forces, nuclear models. Radioactive decay, nuclear reactions, and cross-sections. The interaction of nuclear radiations with matter.

PH 471-472 Solid State Physics (3-0)(3-0)6

[PH 411-412 taken concurrently]

Crystal structure and X-ray and neutron diffraction. Free electron model. Band theory of solids. Quantum mechanical considerations. Lattice energy, lattice vibrations, infrared absorption. Lattice defects. Thermal properties of solids. Dielectric and magnetic properties. Mechanical properties. Semiconductor crystals.

PH 493-494 Advanced Laboratory (0-4)(0-4)2

A laboratory course which may be taken to accompany certain advanced physics courses or which may serve as a vehicle for undergraduate experimental research in a selected field of physics. Open to students whose qualifications are satisfactory.

**PH 501 or 502 The Physics of Color Credits to be
Measurement arranged**

[MA 206, PH 206]

The philosophy and practice of modern colorimetry. Colorimeters, their uses and limitations, spectrophotometers, tristimulus values, dominant wavelength and purity, the "standard observer"

concept, the Munsell system, the Ostwald system, color tolerances, gloss and body color, illuminants, and industrial applications.

Laboratory instruments available consist of brightness testers, monochromatic and trichromatic colorimeters, recording and visual spectrophotometers.

PH 511 Classical Mechanics (3-0)3

Selected topics in analytical dynamics, with emphasis on those most applicable to quantum mechanics and field theory.

PH 514 Statistical Mechanics (3-0)3
[MA 302, PH 324]

Relations between wave mechanics and quantum statistics. Applications of statistical mechanics to the theories of gases, liquids, and solids.

PH 515-516 Advanced Quantum Mechanics (3-0)(3-0)6

Operators and observables. The quantum theory of measurement. Spin and relativistic wave equations. The Dirac theory of the electron, Feynman diagrams, and selected topics in scattering.

PH 518 Relativistic Particle Mechanics (3-0)3
Not offered in 1959-60

PH 523 Low Temperature Physics (3-3)4
[MA 302, PH 222]

The production of low temperatures in various ranges, thermometric problems, the magnetic temperature scale, properties of paramagnetic salts, behavior of specific heats, nuclear polarization and alignment, solid and liquid helium, superfluids, second sound, superconductivity, thermal conductivity at low temperatures, the third law of thermodynamics.

PH 531 Acoustics (3-3)4
Not offered in 1959-60

PH 534 Crystal Vibrations (3-3)4
Not offered in 1959-60

PH 543 or 544 Spectrographic Methods (2-3)3
[PH 206]

The theory and application of the spectrograph for the qualitative and quantitative analysis of materials. The Bohr theory, quantum mechanics, atomic models, and the theoretical prediction of line and band spectra. Special attention is placed in the laboratory on the analysis of elements in paper, leather, and textile samples, and individual problems are assigned to the students.

PH 545 or 546 X-Ray Diffraction (2-3)3

Theory of X-ray production. Absorption. Scattering by electrons and atoms. Crystallographic notation. Laue equations. Determination of crystal structure. For those whose background interests involve fibers, some opportunity for investigation of these is offered in the laboratory work.

PH 547 or 548 Electron Microscopy and (2-3)3
Electron Diffraction

[PH 206, PH 251]

Analogies with optics; electrostatic and magnetic lenses; electron trajectories; solutions of the Laplace and paraxial ray equations; vacuum techniques; the scattering of electrons; electron diffraction: wave properties of the electron, diffraction patterns, crystallographic terminology, reciprocal lattice; replicative, photographic, and other laboratory techniques in electron microscopy and diffraction.

PH 553 Piezoelectricity and Ferroelectricity (3-3)4

Crystallographic bases of piezoelectricity, crystal elasticity, rotated axes, modes of vibration; behavior and interactions of the elastic, dielectric, and piezoelectric coefficients; ferroelectric crystals, domain structure, transitions between phases, free and clamped states; applications of piezoelectric and ferroelectric crystals.

PH 562 Advanced Nuclear Physics (3-0)3

A theoretical course treating the general aspects of nuclear reactions. Alpha and beta decay. Nuclear models and recent advances in nuclear physics.

PH 563 Microwave Spectroscopy (3-3)4
Not offered in 1959-60

PH 565 Nuclear Resonance Methods (3-3)4
Not offered in 1959-60

PH 568 Neutron Diffraction Analysis (3-0)3

The diffraction of neutrons in crystals and its applications in the determination of lattice structures and magnetic moments.

PH 575-576 Problems in Solid State Physics (3-0)(3-3)7

Quantum mechanics and specific heats, lattice energy, elastic coefficients, applications of statistical mechanics, ferroelectric crystals, diamagnetism and paramagnetism, Brillouin zones, Hume-Rothery rules, order-disorder transformations, semiconductors, ferromagnetism and antiferromagnetism, ferrimagnetism, magnetic re-

laxation and resonance, superconductivity, lattice vacancies, diffusion, color centers, excitons, dislocations, thermal and electrical conductivity at low temperatures.

PH 581 **Information Theory** **(3-0)3**
Not offered in 1959-60

PH 583 or 584 **Relativity Theory** **(3-0)3**
Invariance of physical laws. Tensor formulation of the special theory of relativity and applications. The general theory of relativity.

PH 585-586 **Classical Field Theory** **(3-0)(3-0)6**
The theory of electromagnetic fields. Elements of special relativity. The covariance formulation of Maxwell's equations. Applications such as the classical treatment of the field of moving charges, radiation, scattering, and physical optics. Introduction to gravitational fields.

PH 588 **Computers** **(3-0)3**
[MA 302, PH 254]

The principles of analog and digital computers as a basis for assessing and planning their use in scientific work. Logical design, instrumentation, programming, and mathematical analysis and techniques. A survey of the well-known commercial analog and digital computers, and a visit to a local computing center during which a course-programmed problem may be seen.

PH 590 **Field Theory** **(3-0)3**
Not offered in 1959-60

PH 591 or 592 **Graduate Thesis** **Credits to be arranged**

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

PLASTICS

PL 201-202 Plastics Technology I (2-0)(2-0)4

A descriptive subject to acquaint the student with plastics as a class of materials. The history, definitions, classes, properties, and applications of plastics.

PL 301-302 Plastics Technology II (2-2)(2-2)6

[PL 201-202]

Raw materials and manufacturing processes. Methods of processing plastics materials, including compounding, molding, casting, extruding, laminating, fabricating, and finishing. Evaluation and development of typical plastics problems. Laboratory instruction in the processing and fabrication of plastics materials.

PL 401-402 Plastics Technology III (2-3)(2-3)6

[PL 301-302]

Application of plastics as engineering materials. Product, equipment, and mold design. Correlation of composition, processing, and fabrication with product design and applications. Continuation of laboratory instruction in processing, molding, and fabrication.

PL 403-404 Properties of Polymers (2-3)(2-3)6

[Open to seniors only]

Important engineering properties of plastics materials; the theory of testing; examination of testing techniques, equipment, and standard ASTM methods for evaluating mechanical, thermal, electrical, and optical properties.

PL 411-412 Plastics Seminar (1-0)(1-0)2

[Open to seniors only]

Informal discussions, based on literature study conducted by the individual, of topics in, or related to, plastics engineering.

TEXTILES

TE 200 Textile Fibers (4-0)3

[CH 203]

Similar to TE 201 and TE 202, but less detailed. Primary emphasis is upon fiber properties.

TE 201N Technology of Fibers (3-1)3

A study of the important textile fibers, both natural and man-made, from the viewpoints of fiber classifications, origins of natural fibers and production of man-made fibers, geographic distribution, grading, marketing practices, and consumption.

TE 202N Mechanical and Chemical Properties of Fibers (3-0)3

[CH 203, TE 201N]

Classification systems of the important textile fibers in terms of their basic properties. Fundamental mechanical and chemical properties are taken up in detail to provide a basis for understanding the relationship of fiber properties of processing and utilization problems.

TE 210 Fundamentals of Yarns (2-1)2

[EN 205, TE 202N]

Consideration of the theory of making a yarn from staple fibers. The basic processing steps of opening, cleaning, carding, combing, drafting, and spinning are considered from the viewpoint of the mechanical principles involved independently of the particular fiber machinery system employed.

TE 311N Woolen System Yarns (3-3)3

[TE 210]

A study of the processing of textile fibers utilizing the woolen yarns machinery system, including the reclamation of fibers for re-use in the manufacture of yarns.

TE 313-314 Worsted System Yarns (3-3)(3-3)6

[TE 210]

A study of the processing of textile fibers using worsted yarns system machinery. Emphasis is placed upon fundamental aspects of the subject and the integration of this phase with TE 311N and TE 315-316.

TE 315-316 **Cotton System Yarns** **(4-4)(3-3)7**
[TE 210]

[TE 210]

Similar in scope and emphasis to TE 313-314 except that the cotton yarns system machinery is employed.

TE 318 **Filament System Yarns** **(1-1)1**
[TE 210]

[TE 210]

Concerned with the textile steps in processing the various filament yarns, as delivered by the chemical fiber producers, for use by the weaving and knitting elements of the textile industry.

TE 319N Yarns: Cotton and Filament Systems (3-3)3
[TE 210]

[TE 210]

Similar to TE 315-316 and TE 318, but less detailed. Laboratory work consists of demonstrations only.

TE 320 Yarns: Woolen and Worsted Systems (3-3)3
[TE 210]

[TE 210]

Similar to TE 311 and TE 313-314, but less detailed. Laboratory work consists of demonstrations only.

TE 321 Elements of Textiles: Yarns (2-3)3

The basic aspects of fiber properties, fiber preparation, and yarn manufacture by the common machinery systems.

TE 330 **Mechanics of Fabric Design I** **(4-4)4**
[TE 210]

[TE 210]

A study of the fundamental theory and practice relating to the analysis and design of woven structures regardless of the fibers and/or yarns involved. The subject is introduced by presenting the various yarn numbering and classification systems as an integrated whole.

TE 332 **Fundamentals of Fabrics** **(4-4)4**
[TE 319N]

[TE 319N]

The analysis and design of woven fabrics regardless of the fibers and/or yarns involved. Lectures and laboratory demonstrations dealing with the machines and methods for the production of woven fabrics regardless of the fibers and/or yarns employed.

TE 334 **Elements of Textiles: Fabrics** **(2-3)3**

The basic aspects of the production of fabrics by weaving and knitting using common machinery systems.

TE 352N Principles of Textile Operations II (3-3)4

[TE 381]

Designed to cover the processing of fabrics from the loom to the finished state, regardless of construction or fiber content, and including the major steps of purification, coloring, and finishing. The major emphasis is on the mechanical engineering aspects of the processes, with the necessary chemical aspects required to supplement this approach.

TE 381 Principles of Textile Operations I (4-4)4

The elements of fiber preparation, yarn manufacture by all the common systems, weaving, and knitting are presented in an operational units manner, regardless of the fiber involved. Laboratory time consists of demonstrations only.

TE 410 Cotton System Waste Processing (2-2)2

[Permission of instructor]

A study of the methods and machinery employed in processing cotton wastes and/or new cotton on waste machinery. Individual student papers on an assigned topic are presented in class.

TE 411N or 412N Product Quality: Cotton (2-2)2
System Yarns

[Permission of instructor]

Devoted to a study and analysis of product defects in the manufacture of yarns on cotton system machinery. Procedures necessary to avoid the defects are studied, and the diagnostic ability of the student to recognize and remedy defects is developed.

TE 413N or 414N Multifiber Processing: (2-2)2
Cotton System Yarns

[Permission of instructor]

The blending and processing of various fibers utilizing cotton system machinery, with emphasis upon fiber properties and yarn characteristics.

TE 415N-416 Technology of Cotton System Yarns (3-3)(3-3)6

[Permission of instructor]

Restricted to graduate students with a mechanical engineering degree and may be taken to satisfy the undergraduate cotton system yarns requirement. While the scope is similar to TE 315-316, advantage is taken of the mechanical engineering background of the student.

TE 417N-418	Problems in the Technology of Yarns	Credits to be arranged
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[Permission of instructor]

Restricted to qualified students in their senior year. Primarily a laboratory study of desirable spun-yarn properties and the influence of controlled process variables on these properties. Cotton, woolen, or worsted systems machinery may be employed. Emphasis is placed upon actual processing operations to achieve the desired end, the evaluation of the material for conformance to the desired objectives, and the interpretation of results. A final paper is required of each student.

TE 430N	Identification and Classification of Fabrics	(2-0)1
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[Permission of instructor]

Designed to impart knowledge relative to the important fabric types in use in wearing apparel, home furnishings, and industry. An analytical discussion approach is used so that not only may the fabrics be identified but also the significance of the fabric geometry and properties may be grasped.

TE 431N	Mechanics of Fabric Design II	(4-4)4
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[TE 330]

A continuation of TE 330.

TE 433-434N	Technology of Woven Fabrics I and II	(3-3)(3-3)6
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[TE 330, TE 431N concurrently]

Designed to familiarize students with the basic machines and techniques for the production of woven fabrics regardless of the fibers and/or yarns employed, from the preparation of yarns for introduction into a loom to the various loom actions and modifications available for the production of a variety of fabrics. Primary emphasis is upon the mechanical principles employed. This subject is closely integrated with TE 330 and TE 431N.

TE 436	Technology of Knitted Fabrics	(3-3)3
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[TE 330]

Similar in concept and scope to TE 433-434N except that it is devoted to knitted fabrics. A broad survey of the important types of knitting. Considerable stress is placed on the various stitches and the characteristics of fabrics from each. Starting with flat machines, the work advances through small ribbers, automatic hosiery machines, full-fashioned hosiery machines, underwear machines, and warp knitters. The production, design, and analysis of knit fabrics and the classifications and routines for manufacture of hosiery and underwear are included.

TE 438 **Color Theory** (1-1)1

[TE 330 and 431N]

The study of color from a subjective viewpoint utilizing the Munsell Color System, with primary stress placed upon the relation of color to fabric design and structure.

TE 439N or 440N **Fundamentals of Jacquard Fabrics** (1-1)1

[Permission of instructor]

Sketching of original designs as applied to particular Jacquard fabrics, transfer of design to cross-section design paper, choice of weave structure for both the background and foreground, cutting and lacing of cards, and weaving of sample lengths of fabric.

TE 441 or 442 **Complex Woven Structures** (2-1)2

A study of Leavers lace design and production theory, production machinery, and manufacture. The same aspects of Schiffli embroidery are covered, as well as the fundamentals pertaining to chenille, Wilton, Brussels, tapestry, velvet, and Axminster carpets.

TE 443 or 444N **Problems in the Technology of Knitted Fabrics** (3-3)3

[Permission of instructor]

Basically an advanced subject for students interested in the manufacture of knitted fabrics. The student is encouraged to select a particular field from the various sections of the knitting industry and to concentrate on its problems.

TE 445 or 446 **Technology of Woven Fabrics III** (2-2)2

[Permission of instructor]

Additional work concerning the manufacture of woven fabrics. The Crompton & Knowles looms, including the overhead multiplier, filling mixer, and tricolor automatic loom, as well as the dobby looms including leno and terry attachments, the Jacquard heads, harness mounting problems, and carpet manufacture.

TE 447 or 448 **Color Theory** (2-2)2

[Permission of instructor]

Similar in concept to TE 438, but with additional time for the exploration in greater depth of the relation of color to fabric design and structure.

TE 449N **Weaving Laboratory** (0-3)1

[Permission of instructor]

Designed to provide additional time for the student in the weaving laboratory so that greater familiarization with the operation of various loom mechanisms may be acquired.

TE 451-452 Technology of Finishing I (2-1)(0-2)3
[CH 302, EN 311 or 403, TE 330 or 332]

Lectures and laboratory workshops in the major engineering and chemical considerations necessary to finish fabrics of wool and wool blends. The engineering aspects are stressed.

TE 453-454 Technology of Finishing II (2-1)(0-2)3
[CH 302, EN 311 or 403, TE 330 or 332]

Similar in concept and scope to TE 451-452 except that it is devoted to finishing fabrics made of cotton and man-made fibers processed on cotton system machinery.

TE 455-456 Chemical Technology of Finishing I (2-1)(1-2)4
[CH 202, 356, 364; TE 334]

The major aspects in the conversion of fabrics of wool or wool blends for utility, serviceability, or appearance. Stress is placed on the chemical phases but including such engineering aspects as are necessary to supplement and process to completion.

TE 457-458 Chemical Technology of Finishing II (2-1)(1-2)4
[CH 202, 356, 364; TE 334]

Similar in concept and scope to TE 455-456 except that it is devoted to finishing fabrics made of cotton and man-made fibers processed on cotton system machinery.

TE 471 Testing of Textiles I (2-3)3

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equilibrium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 472 Testing of Textiles II (2-3)3

A consideration of basic chemical and optical tools and techniques available to the textile industry for research, development, product control, and end use evaluation. Quantitative and qualitative determination of fiber content, organic and inorganic nonfibrous constituents, evaluation of colorfastness properties, application of the physics of color measurement to dyed textiles, an introduction to microscope optics, and the utilization of microscopy in textile work are among the topics considered.

TE 481 History of Costume and Adaptations (1-2)2

[Permission of instructor]

A general coverage of typical costume through the ages from early Egyptian times to the present. The student is expected to make many modern adaptations inspired by period costumes.

TE 482 Application of Scientific Methods to (3-0)3
Textile Processes

[EN 305 or 403; EN 316 and 407; MA 206]

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483-484 Engineering Design of (3-0)(3-0)6
Textile Structures

[Permission of instructor]

This subject correlates engineering properties of textile materials, engineering principles, and textile processing in the design of textile structures with desired properties. The geometry of yarns and fabrics; design of textile structures for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes which the end use imposes; analyses of load-elongation diagrams of textile structural material.

TE 501N-502N Structure and Properties (3-0)(3-0)6
of Fibers

[Permission of instructor]

The molecular structure and arrangement of molecules in fibers are considered with respect to giving a foundation to the understanding of the physical and mechanical properties and behavior of these textile raw materials. These properties are examined from a fundamental viewpoint so that a sound approach to the technological utilization of fibers in textiles can be established. Such aspects as polymer structure, order, intermolecular forces and flexibility, as they relate to stress-strain characteristics, viscoelastic behavior, etc., are discussed as well as the effects of environmental conditions on these factors. An introduction is made to the interrelation between fiber properties and yarn and fabric geometry in determining the behavior of textiles.

TE 503N or 504N Technology of (2-2)3
Cotton Fibers

[Permission of instructor]

Effects of various chemical, mechanical, and growth modifications of cotton on the chemical, physical, and processing properties of the cotton fiber. Problems are assigned for laboratory evaluation, and a paper for class delivery is required of each student.

TE 511N or 512N Plant Organizations: (2-2)3
Cotton System Yarns
[Permission of instructor]

Designed to correlate the various aspects of yarn production using cotton system machinery. Emphasis is placed upon the need for proper balance among the machinery elements for the production of specific yarn types. Consideration of machinery layouts for efficient and economic operation of the total yarn establishment, with stress on the various calculations involved. Considerable use is made of the case history technique of presentation.

TE 515 or 516N Plant Organization: Woolen (2-2)3
and Worsted System Yarns
[Permission of instructor]

Similar in concept and scope to TE 511N or 512N except devoted to the utilization of woolen and worsted systems machinery.

TE 531 or 532 Plant Organization: (2-2)3
Fabric Production
[Permission of instructor]

Similar in concept and scope to TE 511N or 512N and TE 515 or 516N except that the subject pertains to the production of woven fabrics. Plant layout, production, and work loads for various basic woven fabric constructions are considered.

TE 533 or 534 Kinematics of Looms (2-2)3
[Permission of instructor]

Concerned with a study of loom motions, with emphasis upon instrumentation applications for the securing of pertinent information.

TE 571 or 572 Textile Microscopy (2-3)3
[Permission of instructor]

The principles involved in the use of the microscope for the qualitative and quantitative estimation of the morphological, physical, and chemical properties of textile materials.

TE 573 or 574 Mechanical Testing of Textiles (2-3)3
[Permission of instructor]

Thickness and compressional measurements, stress-strain-time phenomena of viscoelastic textile materials, Vibroscope theory and techniques, yarn uniformity, thermal determination, and friction evaluation are among the major topics covered. Emphasis is placed on current literature search assignments and the preparation of a student paper on a selected topic within the scope of the subject.

TE 581 or 582 Textile Plants Organization (2-2)3

[Permission of instructor]

A study of the numerous factors at the management level leading to the establishment of a textile plant. Location finding, labor supply, materials supply, transportation, community relations, and machinery balance are considered for various types of textile processing plants. The case history technique is used to advantage in this subject.

TE 591N Methods of Research (2-0)1

Required of all graduate students in Textile Engineering during their thesis year. A seminar to familiarize the student with the philosophy of research.

TE 592 Thesis Seminar (2-0)1

Required of all graduate students in Textile Engineering during their thesis year. Devoted to problems in the preparation and presentation of research work, with illustrative material drawn from thesis work in process.

TE 593-594 Graduate Thesis Credits to be arranged

Each graduate student in Textile Engineering is required to submit a thesis which shows ability and originality in the solution and presentation of a research project.

Other subjects pertaining to textiles are listed under Chemistry and Engineering. They are:

CH 302	Introduction to Textile Chemistry	(1-3)2
CH 311	Advanced Quantitative Analysis for Textile Chemists	(2-4)3
CH 355	Chemistry and Physics of Fibers	(3-3)4
CH 356	Chemistry of Fiber Purification	(2-3)3
CH 364	Textile Colloid Chemistry	(4-0)4
CH 401	Introduction to Textile Chemistry	(1-3)2
CH 408	Advanced Studies in Chemistry	Credits to be arranged
CH 422	Chemical Textile Testing	(2-3)3
CH 453	Theory of Dyeing	(3-4)4
CH 454	Industrial Dyeing and Printing	(2-8)4
CH 461	Microbiology	(1-3)2
CH 491	Textile Chemistry Literature Seminar	(2-0)2
CH 501	Color Measurement	(1-3)2
CH 505	Physical Chemistry of Dyeing	(2-3)3
CH 512	The Physical Chemistry of Surface-active Agents	(2-0)2

CH 551 or 552	Textile Testing Problems	(1-3)2
CH 553-554	Evaluation of Finishing Agents	Credits to be arranged
CH 555-556	Textile Chemistry Seminar	(2-0) (2-0)4
CH 559	Instrumental Methods in Textile Research	(1-2)2
CH 561-562	Polymer-Chemical Principles in the Technology of Organic Construction Materials	(3-0) (3-0)6
CH 563-564	Special Topics in the Chemistry and Technology of Manufactured Fibers	(2-0) (2-0)4
EN 429-430	Engineering Design of Textile Structures	(3-0) (3-0)6
EN 492	Application of Scientific Methods to Textile Processes	(3-0)3

The Graduate School

By act of the General Court of 1935, authority was given to the Lowell Technological Institute to confer degrees of Master of Science in the fields of Textile Chemistry, Textile Engineering, and Textile Technology upon graduate students who satisfactorily complete an approved program. More recently, authority has been extended to include graduate programs leading to the Master of Science degree in Paper Engineering, Electronic Engineering, Leather Engineering, Chemistry, and Physics and Mathematics. The latest addition to the Graduate School is a program in Chemistry leading to the Doctor of Philosophy degree. An option in this program allows for specialization in Textile Chemistry.

The graduate programs of study offered by the Institute provide for advanced specialized training required by technologists who contribute to industrial progress and human welfare through the application of scientific and engineering principles to existing industrial and human problems. The courses of study allow the graduate of the Institute, or of other colleges, who has specialized in either textiles, paper, leather, electronics, or chemistry to broaden his knowledge and skills in one of these areas and to develop a sound research approach to problems in the basic sciences, the engineering and development of new products, and industrial production. For those interested in teaching in these fields, the advanced classroom and seminar work, the research experience, and the opportunity to work with recognized leading teachers in the field are important.

ADMISSION TO THE GRADUATE SCHOOL

General Admission

To be eligible for admission to the Graduate School, an applicant must have received a bachelor's degree in an acceptable four-year course in which he has maintained a uniformly high scholastic rating. Both the quality and quantity of previous training will be considered. Selection of those applicants admitted will be based as far as possible on their ability to pursue graduate work of high quality.

Special Student Status

An applicant who meets the general admission requirements, but who wishes to concentrate on certain subjects in specialized techniques, or in some cases on special research programs, may request to be considered for Special Student status. This work does not lead to a degree.

Acceptance as a special student is contingent upon the consent of the instructor in charge of each subject to which admission is desired.

Provisional Status

An applicant for admission who is unable to meet all the requirements for general admission may be accepted provisionally, if he satisfies the department in which he wishes to enroll that he is probably able to pursue graduate studies successfully.

The status of such a student will be changed to that of a graduate student upon demonstration of his ability to pursue graduate studies successfully as measured by the completion of his first semester's work with an average rating of at least B (2.5 or 80%).

Application Procedure

Those wishing to carry on graduate studies at this Institute should file application with the Director of the Graduate School. Applications may be obtained from the Office of the Graduate School.

Applications for admission should be complete and accurate and must be received not later than the first of June preceding the fall term in which the applicant wishes to enroll. Applications must be supported by letters from at least two persons qualified to judge the ability of the applicant to carry on graduate work and research. The letters should be sent directly from these persons to the Graduate School.

Transcripts of all undergraduate records (and graduate, if any) must be sent directly to the Office of the Graduate School by the institutions which the applicant has previously attended. All transcripts must be official, with appropriate seals and signatures. Records, descriptions of subjects, and letters must be in English. Each subject must be described in terms of content, scope, number of hours per week, and number of weeks duration. Lecture and laboratory time should be properly distinguished. If a catalogue giving such descriptions in English is available, the subjects taken may be clearly marked in a copy sent to the Graduate School.

A reading and speaking knowledge of English is necessary for an applicant to be considered for acceptance. Most of the subjects are presented in lecture form, making it difficult for those who do not have a reasonably fluent command of the English language.

Except in unusual circumstances, applications will be acted upon and the applicant notified of the decision by July 1. Foreign applicants are urged to make application as early as possible so as to leave enough time for visa and other arrangements to be made.

GRADUATE COURSES OFFERED

Graduate programs leading to the Master of Science degree are offered in the fields of Chemistry, Electronic Engineering, Leather Engineering, Paper Engineering, Physics and Mathematics, Textile Chemistry, and Textile Engineering. A program leading to the Doctor of Philosophy degree in Chemistry with options in organic, physical, or textile chemistry is also available to qualified applicants.

Because of the varied objectives of the graduate student, the course of study is arrived at through consultation with the student's graduate adviser.

Subjects numbered 500 and above are offered for graduate credit. A limited number of undergraduate subjects are available for graduate credit. The choice of these undergraduate subjects with graduate credit is subject to the approval of the Department Head.

Each program will include an original thesis.

EXPENSES

Tuition, fees, and other expenses for graduate students are for the most part the same as given on page 34 for undergraduates. In addition, however, every graduate student is required to bear the cost of binding two copies of his thesis for the Institute's files. The doctoral candidate must also pay to have his thesis microfilmed. Students will not be permitted to register for thesis work until these fees have been paid at the library.

MASTER OF SCIENCE DEGREE PROGRAMS

Chemistry

This program has been developed to provide opportunity for advanced study and research training in chemistry. Chemistry subjects include both general and specialized fields of study. Provision is also made for the student to elect certain advanced courses in related fields of mathematics, physics, and engineering.

Subject Requirements—Of the 20 credit minimum, exclusive of thesis and seminar required in listed courses (see Requirements for Graduation at the end of this section), a minimum of 15 credits must be taken in chemistry. Of these not more than 12 credits may be taken in approved undergraduate courses designated below by an asterisk, and normally credit will not be allowed in such a course taken in the major field of specialization, e.g., organic, physical, inorganic. Recommended courses include: *CH 403-404, *CH 423-424, *CH 431-432, *CH 443-444, CH 513-514, CH 521-522, CH 523-524, CH 525-526, CH 527, CH 528, CH 529, CH 531-532, CH 533, CH 534, CH 535-536, CH 538, CH 561-562. Each graduate program must include courses in organic chemistry, inorganic chemistry, and physical chemistry. All students must take Chemistry Seminar (CH 507-508). The remaining credits (five or more) may be taken in chemistry or in a related field such as physics, mathematics, or engineering. All subjects must be approved by the student's advisory committee.

Language Requirements—For the degree of Master of Science in Chemistry, the student must demonstrate his ability to read technical German.

Advisory Committee—The development of the student's program of study shall be the responsibility of an advisory committee consisting of three members from the faculty of the Division of Chemistry. This committee shall be appointed by the Director of the Graduate School upon the recommendation of the Division Chairman and shall include the thesis supervisor.

Thesis Examination—Each candidate for a Master of Science degree in Chemistry, upon completion of his thesis, shall present himself for an oral examination in the field of his thesis to an examination committee appointed by the Director of the Graduate School and consisting of his advisory committee and any additional faculty members considered desirable by the Director. While only members of the examination committee and the Director of the Graduate School may conduct the examination, all faculty members may attend. The examination shall be held after the thesis has

been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the Director of the Graduate School at least one month prior to the close of the last semester. Each student has the right to one re-examination within a period of one year.

Electronic Engineering

The graduate program in Electronic Engineering is to be continued in 1959-1960 on a limited basis. The program is restricted to:

- (a) graduates of the Lowell Technological Institute with a B.S. degree in Electronic Engineering, and
- (b) qualified employees of neighboring industrial organizations which are participating in this graduate program.

Leather Engineering

A graduate program in Leather Engineering is offered for students who wish to work extensively in the field of leather technology. In general, only students possessing the B.S. degree in the chemical sciences or in leather engineering will be acceptable as candidates for the degree of Master of Science. In all cases, an examination of the undergraduate record of each candidate will be required before final acceptance. This is particularly necessary in cases where minor specializations in the fields of chemistry or mathematics have not been satisfied; a program based on fulfilling these requirements will then have to be completed with the general requirements for the advanced degree. In the case of students who have not had any leather technology, histology, or bacteriology, a certain portion of the graduate work will of necessity be required in these areas.

The following graduate subjects are offered in the department:

LE 501-502	Tanning Mechanism	(3-0)3
LE 503-504	Microbiological Studies of Leather	(3-5)5
LE 505-506	Graduate Seminar	(1-0)1
LE 507-508	Graduate Thesis and Oral Defense	10
LE 509-510	Microbiology of Skins	(3-5)5

It is suggested that approximately 50% of the graduate program should be chosen from the above subjects with the aid of the Department Head. The remainder should be chosen in fields related to leather technology. Suggested subjects in this area would be:

CH 503	Interpretation of Data	(2-0)2
CH 512	Physical Chemistry of Surface-active Agents	(2-0)2
GS 261-262	Technical German (but not for graduate credit)	

Paper Engineering

The graduate program in Paper Engineering is for the purpose of giving advanced work in papermaking, paper-converting or allied fields.

The Paper Engineering Department will consider graduate students from three different sources:

- (a) graduates of the Lowell Technological Institute B.S. Paper Engineering course;
- (b) paper engineering B.S. and M.S. graduates of other schools;
- (c) general B.S. and M.S. engineering graduates with no previous paper training.

Students with the backgrounds given under (a) and (b) should be able to complete the work in one academic year. Students in group (c) should be able to complete the degree requirements in two academic years.

A graduate student in Paper Engineering will take approximately 50% of his graduate subjects (including thesis) in the Paper Engineering Department. The balance may be taken as electives related to the paper field and approved by the Department.

The graduate subjects offered in this Department are:

PA 501-502	Graduate Thesis	(1-9) (1-9)8
PA 503-504	Plant Design	(4-0) (4-0)8
PA 505-506	Advanced Papermaking and Paper Converting	(2-6) (2-6)8
PA 507-508	Graduate Seminar	(1-0) (1-0)0

Physics and Mathematics

The graduate program in Physics and Mathematics provides an opportunity for advanced study and the development of research capacity in these combined fields, which have a considerable interplay upon each other. An integrated course of study is worked out with each student, who is encouraged to include work in chemistry or other allied fields. Major emphasis may be given to either physics or mathematics, but if the latter, the student is expected to gain appreciation of the applications of mathematics as well as of its rigor.

The laboratories of the Department of Physics and Mathematics are well set up for investigations in crystal physics and other aspects of solid state physics, with excellent equipment in X-rays, spectroscopy, and electron microscopy. The equipment of the Institute in nuclear physics is rapidly increasing.

Subject Requirements—Of the 20 credit minimum, exclusive of thesis, required in listed courses (see Requirements for Graduation at the end of the Graduate School section), 15 credits must be taken in physics and mathematics. The remaining credits (five or more) may be taken in physics and mathematics or in a related field. A

reasonable and consistent program of study is prepared by the student and his advisory committee consisting of two or more members from the faculty of the Division of Engineering, one of whom is the thesis supervisor. This committee is appointed by the Director of the Graduate School upon the recommendation of the Chairman of the Division of Engineering. Entering students who are found to be deficient in any areas of the undergraduate curriculum in Engineering Physics may be required to take appropriate courses in that curriculum.

Language Requirements—For the degree of Master of Science in Physics and Mathematics the student must demonstrate his ability to read scientific German or Russian.

Thesis Examination—Each candidate for a Master of Science degree in Physics and Mathematics, upon completion of his thesis, shall present himself for an oral examination in the field of his thesis to an examination committee appointed by the Director of the Graduate School and consisting of his advisory committee and any additional faculty members considered desirable by the Director. The examination shall be held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the Director of the Graduate School at least one month prior to the close of the last semester. Each student has a right to one re-examination within a period of one year.

Textile Chemistry

Graduate work in Textile Chemistry allows qualified students the opportunity to pursue advanced study in the physical chemistry of textile processing such as dyeing, wet finishing and fiber modification. Studies in the organic chemistry of dyes may also be undertaken. Recent studies have been on the theories of dyeing of natural and synthetic fibers and the application of synthetic finishes. Such studies are carried out by graduate class work, seminars, and original thesis.

The following subjects must be included in the student's program:

First Semester:

CH 503	Interpretation of Data	(2-0)2
CH 505	Physical Chemistry of Dyeing	(2-3)3
CH 531	Chemical Thermodynamics	(3-0)3
CH 555	Textile Chemistry Seminar	(2-0)2

Second Semester:

CH 512	Physical Chemistry of Surface-active Agents	
or		(2-0)2
CH 538	Rheology	
CH 556	Textile Chemistry Seminar	(2-0)2

Recommended electives include CH 561-562 and CH 563-564.

Textile Engineering

The Master of Science in Textile Engineering degree program has been developed so that qualified students may pursue advanced studies in the field of textiles, with primary emphasis upon the mechanical, engineering, or physical aspects of the field. There is a broad enough selection of subjects and research topics so that those interested in the physical and mechanical properties of fibers and textile structures and methods of evaluating them, as well as those who wish to work at an advanced level on textile design, processing, or manufacturing equipment, will have the opportunity to do so.

Candidates—Candidates should preferably possess a B.S. degree in Textile Engineering, Mechanical Engineering, or Electrical Engineering.

Subject Requirements—The program for each student is arrived at after consultation with the Chairman of the Division of Textiles, with the desires and needs of the student being considered. Of the 20 credit minimum, exclusive of thesis, required in listed subjects (see Requirements for Graduation), at least 10 credits must be taken in the area of textiles, and not more than five credits may be taken in the fields of general studies or chemistry. At least an additional five credits must be taken in the field of engineering. All subjects must be approved by the Chairman of the Division of Textiles.

Thesis Examination—Each candidate for a Master of Science degree in Textile Engineering, upon completion of his thesis, shall take an oral examination in the field of his thesis. This examination shall be conducted by a committee appointed by the Director of the Graduate School and consisting of his thesis supervisor and advisers and any additional faculty members considered desirable by the Director. All faculty members may attend, but only members of the Examination Committee may conduct the examination. The examination shall be held after the thesis has been accepted and within a period of two weeks prior to the close of the semester in which the student expects to be a candidate for the degree. Application to take the examination must be filed by the student with the Director of the Graduate School at least one month prior to the close of the designated semester. If the student fails the oral examination, he has the right to one re-examination within a period of one year. Failure in the re-examination will require the satisfactory completion of a new thesis subject.

MASTER OF SCIENCE DEGREE REQUIREMENTS

Term of Residence

Applicants with a sufficient background in their chosen field of concentration will normally require one academic year of residence to complete the requirements for the master's degree. Those with no background will require a minimum of two years of residence.

Graduates of other colleges usually need more than one academic year to fulfill the degree requirements even though they majored as undergraduates in their graduate field of specialization.

Candidacy for a Master's Degree

Admission to a master's degree program does not indicate that the student is a candidate for the master's degree. A student enrolled in a graduate degree program who has established an acceptable scholarship record and has completed half of the required program may make application to the Director of the Graduate School to become a candidate for the degree.

Application for approval of candidacy for the advanced degree must be filed after completion of one-half of the required program and not later than twelve weeks prior to the date on which the degree is to be conferred.

Requirements for Graduation

To be recommended for the Master of Science degree a candidate must have:

- (a) completed a course of study approved by the department in which he has been enrolled. The approved course of study is to have a minimum of 30 credit hours, including thesis. A minimum of 20 credit hours is to be spent in listed subjects, and the program should have no fewer than five credit hours of thesis work.
- (b) completed a thesis (original research or other investigation, optional with department) approved by the department in which he has been enrolled, and successfully passed any oral or written examinations on his thesis required by the department at the time his thesis is submitted for final approval.
- (c) maintained residence for at least one academic year.
- (d) maintained an average rating of B in graduate subjects and passed all undergraduate subjects submitted for graduate credit with a grade of B or better.

DOCTOR OF PHILOSOPHY DEGREE PROGRAM

Chemistry

The doctoral program in Chemistry is designed to provide both advanced knowledge and research training in chemistry, particularly in the fields of organic, physical, and textile chemistry.

Plan of Program

The doctoral degree will normally require from three to four years of study beyond the bachelor's degree, and a minimum of two to three years beyond the master's degree.

The plan of study pursued by each student is dependent on individual requirements and is developed through conference with his advisory committee or, pending its appointment, with his temporary adviser.

Immediately upon entrance, each student is given a set of three evaluation examinations administered by the Chemistry Division in the fields of organic chemistry, physical chemistry, and combined analytical-inorganic chemistry. The results of these examinations will serve as a guide for the student and advisory committee in planning the program of study.

The initial part of the student's program, normally completed at the end of two years of study, is devoted to formal course work. His first year is usually devoted to graduate courses in the major branches of chemistry in preparation for his qualifying (candidacy) examinations. These examinations are taken preferably at or near the end of his third semester. The second year is devoted primarily to advanced courses in a special field of concentration in preparation for the major examinations which are normally taken at the close of his fourth semester of graduate study.

The second and final part of the program is devoted primarily to research leading to the doctoral thesis. However, students are encouraged to begin research as early as possible in their program of study.

Upon entrance to the doctoral program, each student is assigned an advisory committee. This committee is appointed by the Director of the Graduate School, based upon recommendation by the Chairman of the Chemistry Division, and consists of at least three members of the faculty, at least two of whom are from the faculty of the Chemistry Division. One member of the committee representing the student's major field of interest serves as temporary chairman. After the student has selected his thesis supervisor, the

temporary chairman of the advisory committee is replaced by the thesis supervisor, who then serves as permanent chairman.

Course Offerings and Distribution

As a basis for the candidacy examinations, the following core of courses is recommended for first-year students in the doctoral program:

*CH 443-444	Advanced Inorganic Chemistry	(3-0) (3-0)6
CH 513-514	Physicochemical Methods	(2-4) (2-4)6
CH 521-522	Physical Organic Chemistry	(3-0) (3-0)6
CH 531-532	Chemical Thermodynamics	(3-0) (3-0)6

Additional courses may be taken in the minor or in the major field of concentration provided that prerequisites are met.

In the second year, courses supporting concentration in specific fields are available as follows, but selection is not restricted to those subjects listed below in a given field of concentration:

ORGANIC CHEMISTRY

CH 523-524	Organic Chemistry of Polymeric Species	(3-0) (3-0)6
CH 527	Metal-Organic Compounds	(3-0)3
CH 528	Stereochemistry	(3-0)3
CH 529	Heterocyclic Chemistry	(3-0)3

PHYSICAL CHEMISTRY

CH 533	Statistical Mechanics for Chemists	(3-0)3
CH 534	Quantum Mechanics for Chemists	(3-0)3
CH 535-536	Advanced Topics in Physical Chemistry	(3-0) (3-0)6

TEXTILE CHEMISTRY

CH 501	Color Measurement	(1-3)2
CH 505	Physical Chemistry of Dyeing	(2-3)3
CH 512	Physical Chemistry of Surface-active Agents	(2-0)2
CH 538	Rheology	(2-0)2
CH 551 or 552	Textile Testing Problems	(1-3)2
CH 553-554	Evaluation of Finishing Agents	Credits to be arranged
CH 561-562	Polymer Chemical Principles in the Technology of Organic Construction Materials	(3-0) (3-0)6
CH 563-564	Special Topics in the Chemistry and Technology of Manufactured Fibers	(2-0) (2-0)4

Seminar

During each year of residence the student will be required to attend and to participate in graduate seminars. Normally, Chemistry Seminar, CH 507-508, (1-0) (1-0)2, will be taken, but students

*May be taken either for graduate or undergraduate credit.

wishing to specialize in Textile Chemistry may instead elect Textile Chemistry Seminar, CH 555-556, (2-0)(2-0)4, during the first year of study.

Majors and Minors

The prospective candidate is expected to supplement his training in the major field of interest by electing a minor. To avoid overspecialization, this minor must be in a field outside of chemistry. The minor may be divided between two fields if the student so desires. Concentration in the minor field or fields should represent a minimum of nine credits. Subjects in the minor are normally taken during the first two years of study.

DOCTOR OF PHILOSOPHY DEGREE REQUIREMENTS

Term of Residence

Work done only during the regular academic year from September to June can be counted toward residence credit. A minimum of one full academic year of study in residence is required of all candidates. A full year constitutes not less than 36 credit hours of work. Students carrying less than a full-time program must spend a proportionately longer time. Semesters in residence should be consecutive if possible.

All requirements for the doctorate must be completed within seven years after the student's entrance, and within four years after admission to candidacy. Extension of time beyond this limit may be granted only with the joint approval of the student's advisory committee and the Graduate School committee.

Candidacy for the Doctorate

To be admitted to candidacy for the doctorate, a student must have:

- (a) completed the first year's core of advanced courses in physical chemistry, organic chemistry, inorganic chemistry, and physicochemical methods and have had a satisfactory record in undergraduate training, graduate seminar, and collateral reading.
- (b) filed a written request to take the qualifying examinations.
- (c) passed these qualifying examinations which test his general knowledge. One day is devoted to an examination in each of the following areas: organic chemistry, physical chemistry, and combined inorganic-analytical chemistry.
- (d) fulfilled the language requirements, as noted below.
- (e) secured the approval of his advisory committee and the Division Chairman.

When the above requirements have been fulfilled, the Division Chairman will so notify the Director of the Graduate School in writing and recommend that the student be placed on the list of candidates for the Ph.D. degree. Admission to candidacy does not in any way guarantee the granting of the degree.

Requirements for Graduation

To be recommended for the Doctor of Philosophy degree, a candidate must have:

- (a) satisfied the residence requirements.

- (b) pursued an approved program of study that includes the satisfactory completion of at least 90 credit hours beyond the bachelor's degree or equivalent. At least half of these credits will be in formal course work exclusive of seminars or thesis. Graduate credit will be allowed only for grades of C or better in graduate (500) subjects (or certain advanced undergraduate subjects) and B or better in approved undergraduate subjects. An average of B or better must be maintained in graduate subjects which are used for degree credit.
- (c) demonstrated satisfactory reading ability in German and one other language (preferably French or Russian). Foreign students may under certain circumstances substitute their native tongue for one of the languages. Both language examinations must be passed prior to advancement to candidacy and before extensive work on the thesis is begun.
- (d) passed the qualifying examinations for candidacy.
- (e) passed the major examinations in the field of concentration. These examinations are devoted primarily to the testing of the student's knowledge in his special field of concentration and will draw heavily on knowledge gained during his second full year of study in this particular area. They are given only when substantially all of the formal course work has been completed, normally at the end of the second full year (fourth semester). The major examination is in two parts. The first part will be written and will extend over a period of one day. It will test the student's broad knowledge in his specific field of concentration. The second part of the major examination will be oral and will test the student's aptitude for research and his ability to organize and to develop a research problem. The examination will take the form of the defense of a proposition. The student will select a problem with the approval of his advisory committee.
- (f) completed a satisfactory thesis. The doctoral thesis is designed to permit the student to demonstrate his ability to conduct original and independent research work. The results of the thesis investigation should constitute a definite contribution to knowledge in the field of specialization and should be suitable for publication. The field of the thesis investigation should be selected as soon as possible after admission to the graduate program, and the subject of the thesis must be approved by the advisory committee. As soon as the subject has been selected, the student must

make his choice known to the Department Head, who in turn will notify the Graduate School so that the list of theses in progress may be kept current. The thesis subject must be filed not later than two weeks after the student has been admitted to candidacy. While the nature of the results of the thesis investigation provides the basic criterion for determining the time required for the thesis, thesis credit will normally constitute about half of the total credit requirement. As a rule, from three to four semesters of full-time work will be required.

- (g) passed a thesis examination. This is an oral defense of the student's thesis before the faculty of the Department of Chemistry and Textile Chemistry.
- (h) satisfied all requirements as to tuition and fees.

OFFICIAL ROSTER OF GRADUATES

DEGREES CONFERRED IN 1957

Bachelor of Science

Ruben L. Abadi	William Robert King
Yervant Edward Annaian	‡**Vincent William Kulickowski,
John George Arslanian	Jr.
Joseph Bellemore	Joseph William Lahood
Arthur Joseph Berkowitz	Donald Earl Levin
Gerald Edwin Boches	Jacob T. Litt
Martin Lewis Bristow	Frederick Ryeburn Lynch
Philip Bradford Burgess	William Patrick Mahoney
Carlos Antonio Ceppas	Frank William Major
George Arthur Cherry	‡**Frank Vernon Mann
Chris Chingros	Leonard Jay Miller
Hyman Kenneth Cohen	Lewis H. Miller
Leonard T. Coppeta	Plymouth Dixon Nelson
Nicholas Dadoly	Edward Novick
Edward Joseph Delaney	John Joseph O'Keefe
Ernest Elias Deveres	Abraham O. M. Okorodudu
‡Paul Daniel Donovan	‡Rino Louis Pellissier
Robert Huntington Durkee	Jack Austin Perry
Richard Brom Engel	Therese Ann Polak
John Cushier Ferenbach, Jr.	James Edward Powers
‡John Timothy Finnegan	John Thomas Roddy
‡Ronald Alfred Francoeur	‡Roger Edgar Rondeau
Carmen Frank Genzabella	Cornelio B. Sarangaya
Theodore Charles Giras	Richard Cole Savage
Warren Edward Goddard	Richard Earl Sawyer
Roman Golbin	John Herbert Scaringi
Louis Stewart Goldberg	Robert Carl Schiek
Allan Ainley Gwinnell	Richard Arnold Silver
Gerald Floyd Harlam	William Spielman
Richard Arthur Heiden	Bernard Joel Stein
Chris Kapetanakis	Philip Curtis Swain
Robert Herman Keenan	Miguel Teubal
William Bryant Kennerly, Jr.	Harry Norman Tobler
Thomas Michael Keville, Jr.	Adolphe Arthur Traversy
Chawl Whan Kim	Jo Van der Linden

‡Commissioned Second Lieutenant in the United States Air Force Reserve
 **Distinguished AFROTC graduates

Ricardo Villa Escalera
William Rogers Walsh, Jr.
Robert P. L. Yung
Walter C. S. Yung

Maurice George Vacherot
Charles Zaharias
Howard M. Zins

Bachelor of Science with Honors

*Raynal Emile Desrochers
*David Malcolm Hannon
Leo Augustine Hart
*Yashvant Chandulal Jariwala
Leonard Lifland

*Edward Lee McGann
Richard Thomas Meserve, Sr.
‡Peter Gerald Popper
David Laurence Porter

Bachelor of Science with High Honors

*Frances Stephanie Delaney

Master of Science

Robert Chun-Ti Ang *Textile Engineering*
B.E.E., Manhattan College, 1955

Peter Clement Canovai *Textile Chemistry*
B.S., Lowell Technological Institute, 1955

*Allen Albert Denio *Textile Chemistry*
B.S., Lowell Technological Institute, 1956

Edward Walter Makuch *Textile Chemistry*
B.S., Bradford Durfee Technical Institute, 1953

HONORARY DEGREES

Doctor of Science

HIS EXCELLENCY FOSTER FURCOLO
Governor of the Commonwealth

PAUL F. CLARK
Chairman of the Board
John Hancock Mutual Life Insurance Company

HERBERT JAMES BALL
Professor Emeritus, Lowell Technological Institute

*Tau Epsilon Sigma (Lowell Technological Institute Scholastic Honor Society)
‡Commissioned Second Lieutenant in the United States Air Force Reserve

OFFICIAL ROSTER OF GRADUATES

DEGREES CONFERRED IN 1958

Bachelor of Science

William Eugene Archambault	Leon Bernard Golbin
Charles R. Baker	Howard Myron Gorlin
James Philip Bath	James Graham
*Thomas Joseph Bennett	Thomas Edward Greene
Philip Donald Bixby	Nicholas Gregory
Donald Branchaud	†Thomas Robert Hadfield
Alden Reynold Bratt	Leonard Jack Harris
**†Edward Joseph Brennan	Richard Herman
†Theodore Benjamin Brother	Boris Hirmas Rubio
Edward Anthony Buonopane	Robert William Hodge, Jr.
Joseph Burns	William Lyons Kelley
Charles Bernard Campbell	Dae Yee Kim
Augusto Carpio	Robert Julian Kriegel
Robert Carrier	Edward Landy
Edward Phillip Champy, Jr.	Robert Larson
Kathryn Nora Connors	†Vincent Paul Legare
James Noonan Copley	Athena G. Letsou
Paul A. Couture	Joseph Liston
Frederick Daniel Crowe, Jr.	*Charles Ernest Llewellyn, Jr.
Walter Dardano, Jr.	George Alfred Lyna
Arthur N. Dellerson	Robert Henry Mack
Marcellin D. Desrosiers	†Philip Joseph McCall, Jr.
Leo Paul Devarenne	Thomas McCarron
Richard DeVito	Gerald Michael Meehan
Raymond Francis Dunn	Raymond Wilfrid Michaud
Leonard Edelson	Paula Marie Molloy
Sheldon A. Feingold	Paul Elliot Moody
†Joseph John Figiel, Jr.	Donald Moskowitz
†David Fitzgerald	†Vincent Anthony Murdico
Arnold Forsch	James Edward Murray
Joseph Charles Friedrich	Neil Hamilton Murray
John Blake Galvin	Harold Francis Neville, Jr.
Robert Arthur Gardiner	Gilbert Nowell
Elaine Bolton Garside	†Edward Daniel Nowokunski
Roger Albert Gauthier, Jr.	Marino Ocampo
M. Richard Girouard	Clyde Paulauskas
Ernest Glantz	Frederick Francis Pawlowski

Victor Wilmer Proulx
KyuTae Rhee
Wilbert Stephen Rosenberg

†Paul Rene Roussel
Robert Clarence Sanger

*William E. Santos
Gerard Isador Savarese
Philip Joseph Schlueter
Morton Schneider
Anthony Sciola
Bruce Wellington Sharp
Francis Clarence Sharron

*David B. Shaughnessy
*Edward R. Sheldon
Francis Vincent Sherman
†Robert Anthony Silva

Gerald Joseph Smith
Raymond Joseph Snay
Edward Snyder

†Sherman J. Spiegel
Ralph Phillip Stern
Paul Henry Sutherland
†Raymond Bernard Sylvain, Jr.

*Solly Toussieh
Paul Armand Tremblay
†Richard Joseph Urbanek
Vernon Harold Ure
Claire Madeleine Vervaert
Albert John Weil
Robert Joseph Wellspeak
Francis John Wieloch, Jr.
Theodore Raymond Wolnik, Jr.

Roy Jay Zuckerberg

Bachelor of Science with Honors

**†‡John Joseph Carter
‡Walter Preston Cooper
‡Samuel Epstein

†‡Donald Lewis Joyce
‡Alan Crawford McKittrick, Jr.

‡Robert Allen Munroe
‡Robert Bruce Murray
†‡Jack Raymond
‡Charles William Rowntree
‡Mario Joseph Santarelli

Bachelor of Science with High Honors

‡Donald Allan McQuarrie
†‡Joseph Leon Poirier

‡Maurice I. Seifer
‡Earl Forrest Starr, Jr.

Bachelor of Science with Highest Honors

‡Philip Evan Swanson

Master of Science

Remzi Bakirci

Textile Engineering

B.S., Istanbul Technical School, 1954

Joseph Frederic Burt

Textile Engineering

B.T.E., Lowell Technological Institute, 1931

*Degree awarded as of January 31, 1958

†Commissioned Second Lieutenant in the United States Air Force Reserve

‡Tau Epsilon Sigma (Lowell Technological Institute Scholastic Honor Society)

**Distinguished Military Graduate

- | | |
|---|----------------------------|
| Tchang Il Chung | <i>Textile Engineering</i> |
| <i>B.S., Seoul National University, 1955</i> | |
| Constantino Tan Derecho, Jr. | <i>Textile Engineering</i> |
| <i>B.S., University of the Philippines, 1954</i> | |
| Yoon Chai Lee | <i>Textile Chemistry</i> |
| <i>B.A., Kook Min College, 1952</i> | |
| <i>B.S., Rhode Island School of Design, 1957</i> | |
| Shirish B. Mehta | <i>Textile Chemistry</i> |
| <i>B.S., Dharmendrasinji College, 1955</i> | |
| <i>Dip. Tex. Chem., R.C. Technical Institute, Ahmedabad, 1957</i> | |
| Navanitral M. Parekh | <i>Textile Engineering</i> |
| <i>B.Tex., Victoria Jubilee Technical Institute, Bombay, 1957</i> | |
| Louis Port | <i>Textile Chemistry</i> |
| <i>B.S., Rhode Island School of Design, 1952</i> | |
| Roger Edgar Rondeau | <i>Textile Chemistry</i> |
| <i>B.S., Lowell Technological Institute, 1957</i> | |
| Pravikant Sanghani | <i>Textile Chemistry</i> |
| <i>B.Sc., Fergusson College, 1954</i> | |
| <i>B.Sc., Department of Chemical Technology, Bombay, 1956</i> | |
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HONORARY DEGREES

Doctor of Science

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BULLETIN
of the
Lowell Technological Institute
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COURSE OUTLINES
1960-1961

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OFFICIAL ACADEMIC CALENDAR

1960-1961

September 12, Monday . . .	Freshman Orientation Week begins.
September 19, Monday . . .	Registration of seniors and juniors.
September 20, Tuesday . . .	Registration of sophomores and graduate students.
September 21, Wednesday . .	Classes begin.
September 28, Wednesday . .	Last day to register for new classes.
October 11, Tuesday	Last day to drop classes without penalty.
October 12, Wednesday . . .	Columbus Day. Institute closed.
November 11, Friday	Veterans' Day. Institute closed.
November 23, Wednesday, 1 p.m. .	Thanksgiving recess begins.
November 28, Monday	Classes resume.
December 16, Friday, 5 p.m. . .	Christmas recess begins.
January 3, Tuesday	Classes resume.
January 16, Monday	First-semester examinations begin.
January 28, Saturday	End of first semester.
February 6, Monday	
and	Registration of all students.
February 7, Tuesday	
February 8, Wednesday	Classes begin.
February 15, Wednesday	Last day to register for new classes.
February 22, Wednesday	Washington's Birthday. Institute closed.
March 7, Tuesday	Last day to drop classes without penalty.
March 24, Friday, 5 p.m. . . .	Easter recess begins.
April 3, Monday	Classes resume.
April 19, Wednesday	Patriots' Day. Institute closed.
May 20, Saturday	Second-semester examinations begin.
June 9, Friday	End of second semester.
June 11, Sunday	Baccalaureate and Commencement.

General Information

Lowell Technological Institute, founded in 1895, is a coeducational institution of higher learning located in Lowell, Massachusetts, 25 miles north of Boston. It is operated by the Commonwealth of Massachusetts under whose jurisdiction it was placed in 1918. The Institute is a full member in the Senior College Division of the New England Association of Colleges and Secondary Schools. The Engineers' Council for Professional Development extends full accreditation to the curriculum in textile engineering. The chemistry course is accredited by the American Chemical Society.

Affiliated with the Institute is the Lowell Technological Institute Research Foundation, which conducts research, development, testing, and consulting services under contract for responsible agencies and industrial organizations. Headquarters of the American Association of Textile Chemists and Colorists, a national professional organization, have been maintained at the Institute since its inception in 1921.

Requirements for Admission

A candidate for admission must be a graduate of a secondary school approved by the New England Entrance Certificate Board, the Regents of the State of New York, or a board of equal standing. An entering student must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	$\frac{1}{2}$ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

In addition to these prerequisites, each applicant may offer credit in elective subjects. The combined prerequisites and electives should total at least $15\frac{1}{2}$ units. The quality of the applicant's scholastic record and his apparent promise on grounds of intellect and character will be carefully considered.

Further information regarding admission of students with advanced standing, special students, and students from other countries may be obtained from the Director of Admissions.

Application Procedure

Application blanks should be obtained from the Director of Admissions as early as possible after the first marking period in the candidate's senior year of secondary school. The first two pages of the application form should be completed by the candidate and a certified check

or money order in payment of the application deposit of \$10 attached. The form and check should then be submitted to the candidate's secondary-school principal, who will fill out pages 3 and 4 and mail the completed application directly to the Institute's Director of Admissions.

All candidates for admission are required to take the Scholastic Aptitude Test and must make direct application to take this test to the College Entrance Examination Board, P. O. Box 592, Princeton, New Jersey. If the candidate for admission wishes to apply for scholarship aid, he should make formal application for a scholarship to the Institute.

Two copies of a health certificate, which will be provided by the Institute, must be returned to the Director of Admissions, indicating the date of the examination by the applicant's family physician. Each applicant must also file a certificate of residence, completed both by himself and by the city or town clerk of his place of residence. *All admission records, once submitted, become the property of the Institute and will not be returned.*

Upon notification of his acceptance, the applicant must submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll.

A personal interview with the Director of Admissions is strongly recommended. Appointments for interviews should be made in advance. The Office of Admissions is open Monday through Friday from 8:30 A.M. to 5:00 P.M. throughout the year.

Requirements for Graduation

To be recommended for the baccalaureate, each student must complete successfully one of the prescribed curricula with no substitutions for major subjects therein and no unremoved failures in a major subject, must earn a cumulative rating of 1.7 or better for the entire period at the Institute, and must pass 80% of the credit hours offered toward the degree with grades higher than D.

STUDENT EXPENSES

(summarized on a yearly basis)

Tuition

U.S. citizens who are residents of Massachusetts	\$200
U.S. citizens who are residents of states other than Mass.	300
All others	550
Dormitory rate	275
Laboratory and materials fee (all students)	30
Student activity and insurance fee	42
ROTC deposit	25
Books, supplies, and related miscellaneous expenses (approximate)	100

FINANCIAL AID TO STUDENTS

Scholarships

Many scholarships are available to students and prospective students at the Institute through funds contributed by various trusts, organizations, industrial firms, and civic bodies. All entering freshmen who are candidates for scholarships should make direct application to the Director of Admissions and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by April 1.

Fellowships

The Institute has available a limited number of fellowships for graduate studies. More details are available upon request by writing the Director of the Graduate School. Fellowships include:

1. Teaching fellowships. Stipends \$1500 to approximately \$2200. Some teaching is required.
2. Research fellowships.
3. National Science Foundation Cooperative Graduate Fellowships (1961-1962). Applications due early in November, 1960. Teaching may be required.

Loan Fund

A loan fund is available to help upperclassmen to continue their education at the Institute. Students may make application through the Faculty Treasurer of the Lowell Technological Associates, Inc. Those who wish assistance through the National Defense Student Loan Fund should consult the Dean of Students.

Undergraduate Programs

Fourteen fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science. These fields are:

Chemistry	Nuclear Science
Chemical Engineering	Paper Technology
Electrical Engineering	Physics and Mathematics
Electronics Option	Plastics Technology
Industrial Management	Textile Chemistry
Leather Chemistry	Textile Engineering
Mechanical Engineering	Textile Technology
Nuclear Engineering	

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary to enable the Institute better to fulfill its mission of service to industry. Various fields of study are oriented to those industries which constitute 80% of the economy of Massachusetts. Classes in the humanities and social sciences have been woven into all curricula in a conscious effort to produce graduates not only with a thorough technical training but also with the broad cultural background which marks the educated man.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

In most curricula an opportunity is afforded the student to elect subjects in addition to those required for graduation. These electives fall into two categories: Technical Electives and General Electives. Technical Electives give the student a chance to do extra work in his special field or an allied field. General Electives include subjects in languages, literature, social sciences, economics, and management.

The Freshman Program

Orientation

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating the adjustment of the new student to his physical, social and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Industrial Management take the following subjects:

First Semester

*AS	101	Air Science	(0-2)1½
CH	101	General Chemistry	(4-3)4
LL	111	English Composition	(3-0)3
MA	107	Introduction to Mathematical Analysis	(4-0)4
ME	101	Engineering Graphics	(0-3)1
PH	103	Physics	(4-1)4
Total credit hours			16½

Second Semester

†AS	102	Air Science	(2-2)1½
CH	102	General Chemistry	(4-3)4
LL	112	English Composition	(3-0)3
MA	108	Calculus and Analytic Geometry	(5-0)5
ME	102	Engineering Graphics	(0-3)1
PH	104	Physics	(4-1)4
Total credit hours			18½

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education for the whole freshman year. This subject meets one hour per week for AFROTC students and two hours per week for all others. It carries no academic credit.

* Required of all able-bodied, nonveteran male citizens.

† Required of all able-bodied, nonveteran male citizens. Other students must take in its place SS 102, Elements of Political and Economic Geography (2-0)2.

The Air Force ROTC Program

By vote of the Board of Trustees, all able-bodied nonveteran male citizens enrolled in Lowell Technological Institute must satisfactorily complete two years of Air Force Reserve Officers Training Corps courses. In addition to training in leadership these courses include the elements of aerospace power, development of aerial warfare, employment of forces, and operations in space.

Cadets who satisfactorily complete the basic course may apply for the advanced course subject to the recommendation of the Selection Board and the approval of the Professor of Air Science. The advanced course includes principles of leadership and management, effective communications, international relations, and economic and political geography.

Air Science subjects in the junior and senior years may be substituted for General Electives in all curricula unless otherwise specified.

Basic Course

Freshman year, first semester	AS 101	Air Science	(0-2)½
second semester	AS 102	Air Science	(2-2)1½
Sophomore year, first semester	AS 201	Air Science	(2-2)1½
second semester	AS 202	Air Science	(0-2)½

Advanced Course

Junior year,	first semester	AS 301	Air Science	(4-2)2
	second semester	AS 302	Air Science	(2-2)1
		LL 314	Communication of Ideas	(3-0)3
Senior year,	first semester	AS 401	Air Science	(1-2)1½
		SS 403	Economic and Political Geography	(3-0)3
	second semester	AS 402	Air Science	(2-2)1
		SS 459	International Relations	(3-0)3

Chemistry

The curriculum in Chemistry is designed to provide a thorough integrated knowledge and familiarity with the basic techniques in chemistry and in the related sciences of mathematics and physics, supplemented by a background in the humanities to broaden the student's education. Graduates are prepared either for further training at the graduate level or for a professional career in chemistry.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
Total credit hours			18½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
CH	202	Organic Chemistry	(3-3)4
CH	206	Qualitative Analysis	(2-6)4
MA	206	Differential Equations	(3-0)3
or			
MA	384	Statistical Methods	(3-2)4
PH	206	Physics	(3-0)3
		General Elective	
Total credit hours			18½

JUNIOR YEAR

First Semester

CH	321	Organic Chemistry Laboratory II	(0-6)2
CH	331	Physical Chemistry	(3-3)4
EC	201	Principles of Economics I	(3-0)3
LL	261	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
Total credit hours			18

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	342	Organic Qualitative Analysis	(1-6)3
EC	202	Principles of Economics II	(3-0)3
LL	262	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
Total credit hours			19

SENIOR YEAR

First Semester

CH	411	Advanced Quantitative Analysis	(2-4)3
CH	423 or 431 or 443	Advanced Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective	3
			15
Total credit hours			15

Second Semester

CH	424 or 432 or 444	Advanced Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Two Technical Electives	6
			15
Total credit hours			15

Recommended Technical Electives for Juniors and Seniors: CHE 301, 304; TCH 364; CH 481; PH 358, 362, 544, 548. For Seniors only: CH 403-404, 408-409, 423-424, 431-432, and 443-444. Seniors are especially advised to include CH 306 (3-0)3 as a technical elective in the second semester.

Chemical Engineering

The Chemical Engineering curriculum provides training in the fundamentals of unit operations, thermodynamics, and industrial chemistry and in addition includes a thorough background in supporting basic science, engineering science, and mathematics.

SOPHOMORE YEAR

First Semester

AS	201	Air Science	(2-2)1½
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
Total credit hours			18½
*Alternate: SS 223, The United States Since 1865			(2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
CH	202	Organic Chemistry	(3-3)4
CHE	202	Introduction to Chemical Engineering	(3-0)3
LL	214	Introduction to Literature	(3-0)3
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(3-2)4
Total credit hours			17½

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
CHE	301	Industrial Stoichiometry	(3-0)3
CHE	311	Thermodynamics	(3-0)3
EC	201	Principles of Economics I	(3-0)3
*LL	213	Introduction to Literature	(3-0)3
ME	315	Applied Mechanics	(3-0)3
Total credit hours			19

*ROTC students will substitute AS 301 (4-2)2.

Second Semester

CH	332	Physical Chemistry	(3-3)4
CHE	304	Chemical Engineering	(4-0)4
CHE	312	Chemical Engineering Thermodynamics	(3-0)3
EC	202	Principles of Economics II	(3-0)3
ME	372	Strength of Materials	(3-0)3
		General Elective	(3-0)3
Total credit hours			20

SENIOR YEAR

First Semester

CHE 405	Chemical Engineering	(4-0)4
CHE 407	Industrial Chemistry	(3-0)3
CHE 411	Chemical Engineering Laboratory	(0-6)2
	General Elective	(3-0)3
	Two Technical Electives	6

Total credit hours	18
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Second Semester

CH 334	Colloid Chemistry	(3-0)3
CHE 410	Plant Design	(3-0)3
CHE 412	Chemical Engineering Laboratory	(0-6)2
	General Elective	(3-0)3
	Two Technical Electives	6

Total credit hours	17
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Electrical Engineering

ELECTRONICS OPTION

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering with emphasis in electronics.

Students are given a thorough grounding in electrical science and engineering, together with an intensive training in mathematics and physics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture demonstrations in the classroom.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
EC	201	Principles of Economics I	(3-0)3
EE	201	Fundamentals of Electrical Engineering I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(3-2)4

Total credit hours 18½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
EC	202	Principles of Economics II	(3-0)3
EE	202	Fundamentals of Electrical Engineering II	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	212	Applied Mechanics II	(3-0)3
ME	362	Metals Processing	(0-3)1
PH	206	Physics	(3-2)4

Total credit hours 17½

JUNIOR YEAR

First Semester

EE	301	Electronics I	(4-6)6
EE	303	Electromagnetics	(3-0)3
*LL	213	Introduction to Literature	(3-0)3
MA	311	Engineering Mathematics	(4-0)4
ME	341	Thermodynamics	(3-0)3

Total credit hours 19

Second Semester

EE	302	Electronics II	(6-6)8
EE	304	Electromagnetics	(3-0)3
*LL	214	Introduction to Literature	(3-0)3
MA	312	Engineering Mathematics	(4-0)4

Total credit hours 18

*ROTC students will substitute AS 301-302 (4-2)2 (2-2)1 and LL 314, Communication of Ideas (3-0)3.

SENIOR YEAR

Required course: EE 401-402 Feedback Control Systems (3-0) (3-0)6
 plus three Technical Electives and one General Elective
 per semester from the list below.

Minimum total credit hours per semester 15

Technical Electives

EE	403-404	Microwave Electronics	(3-0)(3-0)6
EE	405-406	Communication Electronics	(3-0)(3-0)6
EE	407-408	Pulse and Digital Circuits	(3-0)(3-0)6
EE	409-410	Solid State Physical Electronics	(3-0)(3-0)6
EE	411-412	Logical Design of Digital Computers	(3-0)(3-0)6
EE	413-414	Control System Engineering	(3-0)(3-0)6
EE	415-416	Electromechanical Engineering	(3-3)(3-3)8
EE	421-422	Electronic Project Laboratory	(0-4)(0-4)4
EE	431-432	Special Topics in Electronics	(3-0)(3-0)6
MA	433	Matrix Algebra	(3-0) 3
	and		
MA	484	Calculus of Probabilities	(3-0)3

General Electives: LL 209 or 210, 233, 234, 261-262, 263-264, 265-266
 SS 301, 303, 305, 470, 472, 477 or 478, 479 or 480, 481.

AS 401-402 may be added.

Industrial Management

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide the student with a foundation in science and engineering, in the humanities, and in the social sciences. In addition, the various aspects of management—business organization, production, distribution, accounting, and finance—are studied. The student extends his knowledge of mathematics to include statistics. He is also introduced to the newer research methods, including operations research, linear programming, and game theory. A graduate in this program can expect to find employment as a specialist in accounting, procurement, administration, technical sales, or personnel management.

FRESHMAN YEAR

First Semester

AS	101	Air Science	(0-2)1½
CH	101	General Chemistry	(4-3)4
EC	201	Economics I	(3-0)3
LL	111	English Composition	(3-0)3
MA	107	Introduction to Mathematical Analysis	(4-0)4
ME	101	Engineering Graphics	(0-3)1
Total credit hours			15½

Second Semester

*AS	102	Air Science	(2-2)1½
CH	102	General Chemistry	(4-3)4
EC	202	Economics II	(3-0)3
LL	112	English Composition	(3-0)3
MA	108	Calculus and Analytic Geometry	(5-0)5
ME	102	Engineering Graphics	(0-3)1
Total credit hours			17½
*Alternate:	SS 102, Elements of Political and Economic Geography		(2-0)2

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
EC	211	Economic Statistics	(3-0)3
IM	241	Accounting I	(3-0)3
IM	321	Industrial Marketing	(3-0)3
LL	213	Introduction to Literature	(3-0)3
PH	103	Physics	(4-1)4
Total credit hours			17½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
IM	242	Accounting II	(3-0)3
LL	214	Introduction to Literature	(3-0)3
ME	361	Metals Processing	(0-3)1
PH	104	Physics	(4-2)4
SS	226	Europe Since 1914	(3-0)3
SS	306	Sociology	(3-0)3

Total credit hours 17½

JUNIOR YEAR

First Semester

IM	307	Principles of Finance and Banking	(3-0)3
ME	315	Applied Mechanics	(3-0)3
ME	343	Heat and Power	(2-2)3
ME	373	Engineering Materials	(3-2)3
SS	303	Psychology	(3-0)3

One of the Following Options†

AS	301	(A) Air Science	(4-2)2
IM	443	(B) Industrial Advertising	(3-0)3
IM	341	(C) Accounting III	(3-0)3
MA	205	(D) Calculus and Analytic Geometry	(4-0)4

Total credit hours 17, 18, or 19

Second Semester

EC	302	Labor Economics	(3-0)3
IM	344	Cost Accounting	(3-0)3
IM	464	Business Law	(3-0)3
MA	384	Statistical Methods	(3-0)3
ME	372	Strength of Materials	(3-0)3

One of the Following

AS	302	(A) Air Science	(2-2)1
and			
LL	314	Communication of Ideas	(3-0)3
IM	334	(B) Export Sales Management	(3-0)3
IM	342	(C) Accounting IV	(3-0)3
MA	206	(D) Differential Equations	(3-0)3

Total credit hours 18 or 19

SENIOR YEAR

First Semester

EE	355	Electronic Controls and Power Circuits	(3-2)4
IM	411	Production Management I	(3-0)3
IM	461	Personnel Management	(3-0)3
SS	305	Sociology	(3-0)3

One of the Following

AS	401	(A) Air Science	(1-2)1½
and			
SS	403	Economic and Political Geography	(3-0)3
IM	421	(B) Procurement	(3-0)3
IM	441	(C) Accounting V	(3-0)3
PH	205	(D) Physics	(3-2)4

Total credit hours 16, 16½, or 17

† The specialization sequence selected by the student should be followed through the senior year.

Second Semester

EC	404	Government and Business	(3-0)3
IM	412	Production Management II	(3-0)3
IM	466	Management Problems Seminar	(2-0)2
ME	494	Industrial Instrumentation	(2-0)2
		Special Major Elective	(3-0)3

One of the Following

AS	402	(A) Air Science	(2-2)1
	and		
SS	459	International Relations	(3-0)3
IM	444	(B) Sales Management	(3-0)3
IM	442	(C) Accounting VI	(3-0)3
PH	206	(D) Physics	(3-2)4

Total credit hours	<u>16 or 17</u>
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Leather Chemistry

The Leather Chemistry course is designed to graduate men with a sound background in chemical principles and a thorough understanding of the art of leather manufacturing, in recognition of the fact that the economics, size, and scope of the leather industry warrant the careful training of individuals capable of handling its specific problems.

The basis of this training involves a thorough knowledge of the four major fields of chemistry—inorganic, organic, analytical, and physical. Familiarity with the chemical and physical properties of the main protein constituents of skin is assured by a knowledge of protein chemistry and the practice of the methods of histology. Opportunity for advanced training in one or more of the major fields of chemistry is also provided.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4

Total credit hours 18½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
CH	202	Organic Chemistry	(3-3)4
CH	206	Qualitative Analysis	(2-6)4
LE	202	Introduction to the Principles of Leather Technology	(2-4)3
MA	384	Statistical Methods	(3-0)3
		General Elective	(3-0)3

Total credit hours 17½

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
LE	301	Leather Technology	(3-6)5
LE	303	Leather Histology	(2-4)4
		Two General Electives	(6-0)6

Total credit hours 19

Second Semester

CH	332	Physical Chemistry	(3-3)4
LE	302	Leather Technology	(3-6)5
LE	304	Leather Microbiology	(2-4)4
		Two General Electives	(6-0)6

Total credit hours 19

SENIOR YEAR

First Semester

CH	411	Advanced Quantitative Analysis	(2-4)3
CH	423 or 431 or 443	Advanced Chemistry	(3-0)3
LE	401	Leather Technology	(3-6)5
LE	405	Leather Seminar	(1-0)1
LE	411	Leather Problems	(1-6)3
		General Elective	(3-0)3

Total credit hours 18

Second Semester

CH	424 or 431 or 443	Advanced Chemistry	(3-0)3
LE	402	Leather Technology	(3-6)5
LE	406	Leather Seminar	(1-0)1
LE	412	Leather Problems	(1-6)3
ME	494	Industrial Instrumentation	(2-0)2
		General Elective	(3-0)3

Total credit hours 17

Mechanical Engineering

This course trains the student in the application of the facts and methods of mathematics and science to the design and use of machinery and processes. Principles of design and analysis are stressed in all subjects, and the systems point of view is emphasized.

The student is thoroughly instructed in basic mathematics, physics, and chemistry. There is a unified sequence in applied mechanics which focuses on a course in design given in the senior year. The properties of engineering materials and the principles of thermodynamics, fluid mechanics, and heat transfer are taught, together with a series of subjects in electrical engineering.

In the laboratory the student becomes familiar with typical energy conversion devices and associated controls and instrumentation.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
EC	201	Principles of Economics I	(3-0)3
EE	201	Fundamentals of Electrical Engineering I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(3-2)4
Total credit hours			18½
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
EC	202	Principles of Economics II	(3-0)3
EE	202	Fundamentals of Electrical Engineering II	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	206	Physics	(3-2)4
Total credit hours			16½

JUNIOR YEAR

First Semester

EE	321	Fundamentals of Electrical Engineering III	(2-2)3
MA	383	Statistical Methods	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	361	Metals Processing	(0-3)1
ME	375	Engineering Materials	(3-2)3
		General Elective	(3-0)3
Total credit hours			19

Second Semester

EE	324	Electrical Machinery	(3-2)4
ME	314	Mechanical Engineering Laboratory I	(0-3)1
ME	318	Applied Mechanics IV	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	364	Physical Metallurgy	(3-0)3
		General Elective	(3-0)3
Total credit hours			17

SENIOR YEAR

First Semester

EE	415	Electromechanical Engineering	(3-3)4
ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	431	Power Plant Systems	(2-3)3
ME	481	Fluid Mechanics	(3-0)3
		General Elective	(3-0)3
Total credit hours			17

Second Semester

EE	416	Electromechanical Engineering	(3-3)4
EE	418	Engineering Systems Analysis	(2-0)2
ME	416	Mechanical Engineering Laboratory III	(0-3)1
ME	422	Machine Design	(2-3)3
ME	442	Air Conditioning	(2-3)2
or			
ME	472	Experimental Stress Analysis	(2-2)2
ME	444	Heat Transfer	(3-0)3
		General Elective	(3-0)3
Total credit hours			18

NOTE: General Electives must all be chosen either from Group A or from Group B, not from both.

GROUP A

LL	213	Introduction to Literature	(3-0)3
LL	214	Introduction to Literature	(3-0)3
LL	473	The Modern American Novel	(3-0)3
LL	474	Modern Drama	(3-0)3

GROUP B

SS	226	Europe Since 1914	(3-0)3
SS	470	Comparative Modern Governments	(3-0)3
SS	481	The Greeks and Western Civilization	(3-0)3
SS	482	The Romans and Western Civilization	(3-0)3

Nuclear Engineering

The Nuclear Engineering course is the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education as well as special training in the nuclear field. The student is prepared both for responsible positions in industry and graduate studies.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
EC	201	Principles of Economics	(3-0)3
EE	201	Fundamentals of Electrical Engineering I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(3-2)4

Total credit hours 18½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
EC	202	Principles of Economics	(3-0)3
EE	202	Fundamentals of Electrical Engineering II	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	206	Physics	(3-2)4

Total credit hours 16½

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	363	Physical Metallurgy	(3-0)3
PH	343	Atomic Physics	(3-0)3
		General Elective	(3-0)3

Total credit hours 18

Second Semester

MA	302	Advanced Calculus	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	482	Fluid Mechanics	(3-0)3
NU	302	Nuclear Radiation and Radiological Safety	(3-0)3
PH	362	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3

Total credit hours 18

SENIOR YEAR

First Semester

CH	481	Nuclear Chemistry and Radiochemistry	(3-3)4
NU	401	Nuclear Engineering I	(3-0)3
NU	403	Reactor Instrumentation I	(2-4)3
NU	405	Reactor Operations and Analysis I	(3-2)4
PH	461	Nuclear Physics	(3-0)3
		General Elective	(3-0)3

Total credit hours	20
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Second Semester

ME	444	Heat Transfer	(3-0)3
NU	402	Nuclear Engineering II	(3-0)3
NU	404	Reactor Instrumentation II	(2-4)3
NU	406	Reactor Operations and Analysis II	(3-2)4
PH	462	Nuclear Physics	(3-0)3
		General Elective	(3-0)3

Total credit hours	19
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Nuclear Science

The course in Nuclear Science is the first to be offered by a publicly supported institution in New England. The curriculum emphasizes those fundamental subjects in physics and mathematics necessary for a basic education in all sciences and thus prepares the graduate for advanced studies as well as for responsible positions in industry.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
LL	261	Elementary Technical German	(3-0)3
or			
LL	265	Elementary Technical Russian	(4-0)4
MA	205	Calculus and Analytic Geometry	(3-2)4
PH	205	Physics	(3-0)3
PH	211	Intermediate Mechanics	(3-3)4
PH	251	Intermediate Electricity	

Total credit hours 19½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
LL	262	Elementary Technical German	(3-0)3
or			
LL	266	Elementary Technical Russian	(3-0)3
MA	206	Differential Equations	(3-2)4
PH	206	Physics	(3-0)3
PH	222	Intermediate Thermodynamics	(3-3)4
PH	254	Electronics	

Total credit hours 17½

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
NU	301	Nuclear Radiation and Radiological Safety	(3-0)3
PH	311	Physical Mechanics	(3-0)3
PH	343	Atomic Physics	(2-3)3
PH	357	Electrical Measurements	(3-0)3
		General Elective	

Total credit hours 18

Second Semester

MA	302	Advanced Calculus	(1-4)3
NU	352	Nuclear Instrumentation I	(3-0)3
PH	324	Statistical Mechanics	(3-0)3
PH	354	Electromagnetic Theory	(3-0)3
PH	362	Intermediate Nuclear Physics	(3-0)3
		General Elective	

Total credit hours 18

SENIOR YEAR

First Semester

CH	481	Nuclear Chemistry and Radiochemistry	(3-3)4
MA	433	Matrix Algebra	(3-0)3
PH	411	Quantum Mechanics	(3-0)3
PH	461	Nuclear Physics	(3-0)3
PH	471	Solid State Physics	(3-0)3
		General Elective	(3-0)3

Total credit hours 19

Second Semester

MA	484	Calculus of Probabilities	(3-0)3
NU	452	Nuclear Instrumentation II	(2-4)3
PH	412	Quantum Mechanics	(3-0)3
PH	462	Nuclear Physics	(3-0)3
PH	472	Solid State Physics	(3-0)3
		General Elective	(3-0)3

Total credit hours 18

Paper Technology

The object of the Paper Technology course is to fit a man for work in the papermaking, paper-converting, or allied industries. A thorough training in basic chemical engineering is offered, accompanied by instruction in the theory and practice of pulp and paper manufacture and paper converting. Paper Technology involves the application of cellulose and plastics chemistry together with engineering principles to the handling of the material in the web or sheet form, as it is treated, coated, or converted into the final product.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
CH	201	Organic Chemistry	(3-3)4
LL	213	Introduction to Literature	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	315	Applied Mechanics	(3-0)3
PH	205	Physics	(3-2)4

Total credit hours 19½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
CHE	202	Introduction to Chemical Engineering	(3-0)3
ME	372	Strength of Materials	(3-0)3
PH	206	Physics	(3-2)4

Total credit hours 19½

JUNIOR YEAR

1960-1961 only

First Semester

CH	331	Physical Chemistry	(3-3)4
CHE	301	Industrial Stoichiometry	(3-0)3
*LL	213	Introduction to Literature	(3-0)3
PA	301	Pulp Technology	(3-0)3
PA	303	Pulp Laboratory	(2-6)4
		Technical Elective	(3-0)3

Total credit hours 20

*ROTC students will substitute AS 301 (4-2)2.

Second Semester

CH	332	Physical Chemistry	(3-3)4
CHE	304	Chemical Engineering	(4-0)4
ME	372	Strength of Materials	(3-0)3
PA	302	Paper Technology	(3-0)3
PA	304	Paper Laboratory	(1-6)3
		General Elective	(3-0)3

Total credit hours 20

JUNIOR YEAR
Effective 1961-1962

First Semester

CH 331	Physical Chemistry	(3-3)4
CHE 301	Industrial Stoichiometry	(3-0)3
CHE 311	Chemical Engineering Thermodynamics	(3-0)3
PA 301	Pulp Technology	(3-0)3
PA 303	Pulp Laboratory	(2-6)4
	General Elective	(3-0)3

Total credit hours 20

Second Semester

CH 332	Physical Chemistry	(3-3)4
CHE 304	Chemical Engineering	(4-0)4
CHE 312	Chemical Engineering Thermodynamics	(3-0)3
PA 302	Paper Technology	(3-0)3
PA 304	Paper Laboratory	(1-6)3
	General Elective	(3-0)3

Total credit hours 20

SENIOR YEAR

First Semester

CHE 311	Chemical Engineering Thermodynamics	(3-0)3
CHE 441	Chemical Engineering	(3-0)3
EE 355	Electronic Controls and Power Circuits	(3-2)4
PA 403	Converting Technology	(3-0)3
PA 405	Converting Laboratory	(1-6)3
	General Elective	(3-0)3

Total credit hours 19

Second Semester

ME 494	Industrial Instrumentation	(2-0)2
PA 414	Paper Problems	(2-6)4
TCH 364	Textile Colloid Chemistry	(4-0)4
	General Elective	(3-0)3
	Technical Elective	3

Total credit hours 16

SENIOR YEAR
Effective 1962-1963

First Semester

CHE 405	Chemical Engineering	(4-0)4
CHE 411	Chemical Engineering Laboratory	(0-6)2
PA 403	Converting Technology	(3-0)3
PA 405	Converting Laboratory	(1-6)3
PA 413	Paper Problem Reports	(1-0)1
	General Elective	(3-0)3
	Technical Elective	3

Total credit hours 19

Second Semester

CH 334	Colloid Chemistry	(3-0)3
CHE 410	Plant Design	(3-0)3
PA 412	Wood Chemistry	(3-0)3
PA 414	Paper Problems	(1-6)3
	General Elective	(3-0)3
	Technical Elective	3
		<hr/>
Total credit hours		18

Physics and Mathematics

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics and mathematics. It should be contemplated only by those with superior competence in mathematics.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
LL	261	Elementary Technical German	
	or		(3-0)3
LL	265	Elementary Technical Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
PH	211	Intermediate Mechanics	(3-0)3
PH	251	Intermediate Electricity	(3-3)4
Total credit hours			19½
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Air Science	(0-2)½
LL	262	Elementary Technical German	
	or		(3-0)3
LL	266	Elementary Technical Russian	
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(3-2)4
PH	222	Intermediate Thermodynamics	(3-0)3
PH	254	Electronics	(3-3)4
Total credit hours			17½

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
PH	311	Physical Mechanics	(3-0)3
PH	343	Atomic Physics	(3-1)3
PH	353	Electromagnetic Theory	(3-0)3
PH	355	Physical Electronics	(3-0)3
		General Elective	(3-0)3
Total credit hours			18

Second Semester

MA	302	Advanced Calculus	(3-0)3
PH	324	Statistical Mechanics	(3-0)3
PH	358	Electrical Measurements	(2-3)3
PH	362	Intermediate Nuclear Physics	(3-0)3
		Two General Electives	(6-0)6
Total credit hours			18

SENIOR YEAR

First Semester

MA	433	Matrix Algebra	(3-0)3
PH	411	Quantum Mechanics	(3-0)3
PH	461	Nuclear Physics	(3-0)3
PH	471	Solid State Physics	(3-0)3
PH	493	Advanced Laboratory	(0-4)1
		Two General Electives	(6-0)6
			19
Total credit hours			

Second Semester

MA	484	Calculus of Probabilities	(3-0)3
PH	412	Quantum Mechanics	(3-0)3
PH	462	Nuclear Physics	(3-0)3
PH	472	Solid State Physics	(3-0)3
PH	494	Advanced Laboratory	(0-4)1
		One Technical Elective	3
		One General Elective	(3-0)3
			19
Total credit hours			

General Electives are to be chosen as follows:

At least two subjects from Group A and at least two subjects from Group B.

Group A

SS 101, 102, 223, 224, 226, 301, 303, 305, 470, 472, 477 or 478, 479 or 480, 481.

Group B

LL 213, 214, 233, 234, 265, 266, 361, 361a, 362, 362a, 365, 366, 406, 473.

Plastics Technology

The training of personnel specifically prepared to cope with the many technical and production problems found in the expanding field of plastics fabrication is the objective of the course in Plastics Technology. Emphasis is on the engineering principles involved in the fabrication of plastics materials into useful forms rather than the chemistry involved in the manufacture of the plastics material itself. However, the curriculum involves considerably more chemistry than most engineering courses, owing to the close relationship between the physical and chemical properties of such materials. Problems of design, manufacture, and testing in the plastics industry are closely studied.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
CH	201	Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(2-6)4
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
PL	201	Plastics Technology I	(2-0)2
Total credit hours			19½
*Alternate: SS 223, The United States Since 1865			(2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
MA	384	Statistical Methods	(3-0)3
PH	206	Physics	(3-2)4
PL	202	Plastics Technology I	(2-0)2
Total credit hours			18½

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
*EC	201	Principles of Economics I	(3-0)3
EE	355	Electronic Controls and Power Circuits	(3-2)4
ME	261	Machine Tool Laboratory	(1-2)1
ME	315	Applied Mechanics	(3-0)3
PL	301	Plastics Technology II	(2-2)3
Total credit hours			18

*ROTC students will substitute AS 301 (4-2)2.

Second Semester

CH	332	Physical Chemistry	(3-3)4
*EC	202	Principles of Economics II	(3-0)3
ME	372	Strength of Materials	(3-0)3
ME	374	Plastics Mold Design and Construction	(1-2)1
ME	376	Engineering Materials	(3-2)3
PL	302	Plastics Technology II	(2-2)3

Total credit hours 17

*ROTC students will substitute AS 302 (2-2)1 and LL 314, Communication of Ideas (3-0)3.

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-3)4
PL	401	Plastics Technology III	(2-3)3
PL	403	Properties of Polymers	(4-0)4
PL	411	Plastics Seminar	(1-0)1
		Two Electives	(6-0)6

Total credit hours 18

Second Semester

CH	404	Chemistry of High Polymers	(3-3)4
ME	482	Fluid Mechanics	(3-0)3
ME	494	Industrial Instrumentation	(2-0)2
PL	402	Plastics Technology III	(2-3)3
PL	404	Properties of Polymers	(0-3)1
PL	412	Plastics Seminar	(1-0)1
		Elective	(3-0)3

Total credit hours 17

Electives

CH	306	Atomic and Molecular Structure	(3-0)3
CH	423-424	Advanced Organic Chemistry	(3-0) (3-0)6
IM	483 or 484	Statistical Quality Control	(3-0)3
LL	261-262	Elementary Technical German	(3-0) (3-0)6
MA	206	Differential Equations	(3-0)3
MA	487 or 488	Advanced Statistical Methods	(3-0)3

Textile Chemistry

A sound foundation in basic chemistry and a knowledge of chemical applications in textiles and in textile processes are combined in the Textile Chemistry course to provide a specialized training for chemists planning to work in the textile industry or in related chemical industries producing auxiliary chemicals and fibers.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4

Total credit hours 18½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)½
CH	202	Organic Chemistry	(3-3)4
CH	206	Qualitative Analysis	(2-6)4
MA	384	Statistical Methods	(3-0)3
PH	206	Physics	(3-2)4
		General Elective	3

Total credit hours 18½

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
CH	411	Advanced Quantitative Analysis	(2-4)3
EC	201	Principles of Economics I	(3-0)3
TCH	355	Chemistry and Physics of Fibers	(3-3)4
TE	321	Elements of Textiles: Yarns	(2-3)3
		General Elective	(3-0)3

Total credit hours 20

Second Semester

CH	332	Physical Chemistry	(3-3)4
EC	202	Principles of Economics II	(3-0)3
TCH	356	Chemistry of Fiber Purification	(3-3)4
TCH	364	Textile Colloid Chemistry	(4-0)4
TE	334	Elements of Textiles: Fabrics	(2-3)3
		General Elective	(3-0)3

Total credit hours 21

SENIOR YEAR

First Semester

CH	425	Organic Chemistry of Colored Substances	(2-0)2
CH	453	Theory of Dyeing	(3-4)4
TE	455	Chemical Technology of Finishing I	(2-1)2
TE	457	Chemical Technology of Finishing II	(2-1)2
TE	471	Testing of Textiles I	(2-3)3
		Electives (at least one must be a General Elective)	6

Total credit hours 19

Second Semester

TCH	422	Chemical Textile Testing	(2-3)3
TCH	454	Industrial Dyeing and Printing	(2-8)4
TE	456	Chemical Technology of Finishing I	(1-2)2
TE	458	Chemical Technology of Finishing II	(1-2)2
		Electives (at least one must be a General Elective)	6

Total credit hours 17

Textile Engineering

This course is based on a sound training in mathematics and science and their application to the solution of technical problems. The curriculum is similar to and related to that in mechanical engineering but includes sufficient subjects in textile science to qualify the student for positions in either production or research in the textile industry.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
EC	201	Principles of Economics I	(3-0)3
EE	201	Fundamentals of Electrical Engineering I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(3-2)4

Total credit hours 18½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)1½
EC	202	Principles of Economics II	(3-0)3
EE	202	Fundamentals of Electrical Engineering II	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	206	Physics	(3-2)4

Total credit hours 16½

JUNIOR YEAR

First Semester

EE	321	Fundamentals of Electrical Engineering III	(2-2)3
MA	383	Statistical Methods	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
TE	381	Principles of Textile Operations I	(4-4)4
		General Elective	(3-0)3

Total credit hours 19

Second Semester

EE	324	Electrical Machinery	(3-2)4
ME	314	Mechanical Engineering Laboratory I	(0-3)1
ME	342	Thermodynamics	(3-0)3
ME	376	Engineering Materials	(3-2)3
TE	352N	Principles of Textile Operations II	(3-3)4
		General Elective	(3-0)3

Total credit hours 18

SENIOR YEAR

First Semester

EE	415	Electromechanical Engineering	(3-3)4
ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	481	Fluid Mechanics	(3-0)3
TE	471	Testing Textiles I	(2-3)3
TE	483	Engineering Design of Textile Structures	(3-0)3
		General Elective	(3-0)3
Total credit hours			20

Second Semester

EE	418	Engineering Systems Analysis	(2-0)2
ME	416	Mechanical Engineering Laboratory III	(0-3)1
ME	422	Machine Design	(2-3)3
ME	444	Heat Transfer	(3-0)3
TE	482	Application of Scientific Methods to Textile Processes	(3-0)3
TE	484	Engineering Design of Textile Structures	(3-0)3
		Elective	(3-0)3
Total credit hours			18

NOTE: General Electives must all be chosen either from Group A or from Group B, not from both.

GROUP A

LL	213	Introduction to Literature	(3-0)3
LL	214	Introduction to Literature	(3-0)3
LL	473	The Modern American Novel	(3-0)3
LL	474	Modern Drama	(3-0)3

GROUP B

SS	226	Europe Since 1914	(3-0)3
SS	470	Comparative Modern Governments	(3-0)3
SS	481	The Greeks and Western Civilization	(3-0)3
SS	482	The Romans and Western Civilization	(3-0)3

Textile Technology

This course of study is designed to equip its students with a well-rounded understanding of the theory and principles relating to the processing of textile materials. At the same time it provides the scientific basis necessary to understand and apply this technological knowledge. Basic purpose of the program is to prepare students to become competent textile technologists for eventual supervisory, administrative, or executive positions within the industry and its allied fields. To achieve this end, a comprehensive course covers the basic theory, principles, and applications of the major phases of textile manufacture utilizing all the common fibers, both natural and man-made, and all fabricating processes.

SOPHOMORE YEAR

First Semester

*AS	201	Air Science	(2-2)1½
CH	203	Elementary Organic Chemistry	(3-0)3
LL	213	Introduction to Literature	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(3-2)4
TE	201N	Technology of Fibers	(3-1)3

Total credit hours 18½

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Air Science	(0-2)½
LL	210	Speech	(2-0)2
ME	212	Applied Mechanics I	(3-0)3
ME	262	Machine Tool Laboratory	(1-2)1
PH	206	Physics	(3-2)4
TE	202N	Mechanical and Chemical Properties of Fibers	(3-0)3
TE	210	Fundamentals of Yarns	(2-1)2
TE	282	Textile Mechanisms	(2-3)3

Total credit hours 18½

JUNIOR YEAR

First Semester

*EC	201	Principles of Economics I	(3-0)3
MA	383	Statistical Methods	(3-0)3
ME	343	Heat and Power	(2-2)3
TE	311N	Woolen System Yarns	(3-3)3
TE	313	Worsted System Yarns	(3-3)3
TE	315	Cotton System Yarns	(4-4)4

Total credit hours 19

*ROTC students will substitute AS 301 (4-2)2.

Second Semester

*EC	202	Principles of Economics II	(3-0)3
EE	352	Industrial Electronics	(3-1)3
TCH	302	Introduction to Textile Chemistry	(1-3)2
TE	314	Worsted System Yarns	(3-3)3
TE	316	Cotton System Yarns	(3-3)3
TE	318	Filament System Yarns	(1-1)1
TE	330	Mechanics of Fabric Design I	(4-4)4

Total credit hours 19

*ROTC students will substitute AS 302 (2-2)1 and LL 314, Communication of Ideas (3-0)3.

SENIOR YEAR

First Semester

*SS	303	Psychology	(3-0)3
TCH	401	Introduction to Textile Chemistry	(1-3)2
TE	431N	Mechanics of Fabric Design II	(4-4)4
TE	433	Technology of Woven Fabrics I	(3-3)3
TE	451	Technology of Finishing I	(2-1)2
TE	453	Technology of Finishing II	(2-1)2
TE	471	Testing of Textiles I	(2-3)3

Total credit hours 19

*ROTC students will substitute AS 401 (1-2)½ and SS 403, Economic and Political Geography (3-0)3.

Second Semester

*SS	470	Comparative Modern Governments	(3-0)3
TE	434N	Technology of Woven Fabrics II	(3-3)3
TE	436	Technology of Knitted Fabrics	(3-3)3
TE	438	Color Theory	(1-1)1
TE	452	Technology of Finishing I	(0-2)1
TE	454	Technology of Finishing II	(0-2)1
TE	472	Testing of Textiles II	(2-3)3
TE	474	Instrumentation for Textiles	(2-2)3

Total credit hours 18

*ROTC students will substitute AS 402 (2-2)1 and SS 459, International Relations (3-0)3.

The Graduate School

Graduate programs leading to the Master of Science degree are offered in the fields of Chemistry, Electrical Engineering (Electronics Option), Leather Chemistry, Paper Technology, Physics and Mathematics, Textile Chemistry, and Textile Engineering. A program leading to the Doctor of Philosophy degree in Chemistry is also available. For the most part, the course of study is determined through consultation with the student's graduate adviser. Each program will include a thesis.

Admission

An applicant must have received (or be about to receive) a bachelor's degree and maintained uniformly high scholarship. The applicant must also take the Graduate Record Aptitude Test.

Application Procedure

Those wishing to conduct graduate studies at the Institute must:

1. File application with the Director of the Graduate School on forms available by June 1 of the year in which they wish to enroll.
2. Have official transcripts of undergraduate record (and graduate, if any) sent directly to the Office of the Graduate School from the institutions previously attended.
3. Apply to the Educational Testing Service, 20 Nassau Street, Princeton, New Jersey, or Box 27896, Los Angeles 27, California (whichever office is nearer to the applicant), to take the Graduate Record Aptitude Test. Applicants from foreign countries are urged to apply for the test given during November of the year prior to the September in which they wish to enroll. They should not take the test later than the January test date.
4. In cases where there is doubt about the undergraduate background, subject descriptions and other supporting information may be required.

Expenses

Tuition and fees are for the most part the same as given on page 4 for undergraduates. In addition, every graduate student must pay a thesis-binding fee for at least two copies of his thesis. The doctoral candidate must pay to have his thesis microfilmed.

Master of Science Degree Programs

Chemistry

This program has been developed to provide opportunity for advanced study and research training in chemistry. Chemistry subjects include both general and specialized fields of study. Provision is also

made for the student to elect certain advanced courses in related fields of mathematics, physics, and engineering.

Electrical Engineering

This program will be continued in 1960-1961 on a limited basis. The program is restricted to graduates of Lowell Technological Institute with a B.S. degree in the same field and to qualified employees of neighboring industrial organizations which are participating in this graduate program.

Leather Chemistry

In general, only students possessing the B.S. degree in the chemical sciences or in the field of leather will be acceptable as candidates for the degree of Master of Science in this area. Approximately 50% of the graduate program should be chosen from subjects in the field of leather chemistry, the remainder from other graduate courses of the Institute. A thesis and its defense constitute a major portion of the program in which selected to demonstrate the student's ability to do independent research.

Paper Technology

This graduate program is for the purpose of giving advanced work in papermaking, paper-converting, or allied fields. Students with previous training in paper technology should be able to complete the work in one academic year. A graduate student in Paper Technology will take approximately 50% of his graduate subjects (including thesis) in the Paper Technology Department.

Physics and Mathematics

The graduate program in Physics and Mathematics provides an opportunity for advanced study and the development of research capacity in these combined fields. Major emphasis may be given to either field. The laboratories of the Department provide adequate facilities for investigations in crystal physics and other aspects of solid state physics, with excellent equipment in X-rays, spectroscopy, and electron microscopy.

Textile Chemistry

Graduate work in Textile Chemistry allows qualified students the opportunity to pursue advanced study in the chemistry of textile processing such as dyeing, wet finishing, and fiber modification. Thesis investigations in the above fields are supplemented by course work in the physical chemistry of dyeing, the physical chemistry of surfactants, rheology, textile chemistry seminar, and elective advanced subjects in chemistry.

Textile Engineering

This graduate program places primary emphasis on the mechanical engineering or physical aspects of the field. Candidates preferably should

possess a Bachelor of Science degree in textile engineering, mechanical engineering, or electrical engineering. A minimum of 20 credits must be taken in academic subjects, of which at least one-half must be in the field of textiles, and a suitable thesis must account for a minimum of 5 credits. An oral defense of the thesis is required.

MASTER OF SCIENCE DEGREE REQUIREMENTS

Term of Residence

Either one or two full academic years are normally needed to complete the Master of Science degree requirements, depending on the undergraduate background of the applicant.

Requirements for Graduation

To be recommended for the Master of Science degree, a candidate must:

1. Complete with satisfactory grades an approved course of study having a minimum of 30 credit hours, including thesis (a minimum of 20 credit hours in subjects and a minimum of 5 credit hours of thesis).
2. Complete a thesis and pass any examinations on it that may be required.
3. Maintain residence for at least one academic year.

DOCTOR OF PHILOSOPHY DEGREE PROGRAM

Chemistry

The doctoral program in Chemistry is designed to provide both advanced knowledge and research training in chemistry, particularly in the fields of organic and physical chemistry. Advanced training in polymer chemistry with emphasis in the field of textiles is also available.

The doctoral degree will normally require from three to four years of study beyond the bachelor's degree and a minimum of two to three years beyond the master's degree. The plan of study pursued by each student is dependent on individual requirements and is developed through conference with a faculty committee or, pending its appointment, with a temporary adviser.

DOCTOR OF PHILOSOPHY DEGREE REQUIREMENTS

Term of Residence

Normally three or four full academic years are needed to complete the Doctor of Philosophy degree. At least one full academic year of study in residence is required of all candidates. (A full year constitutes at least 36 credit hours of work.) All requirements must be completed within seven years.

Candidacy for the Doctorate

To be admitted to candidacy, a student must:

1. Complete the first year of advanced subjects and maintain a satisfactory record.
2. Pass qualifying examinations.
3. Complete the language requirements.

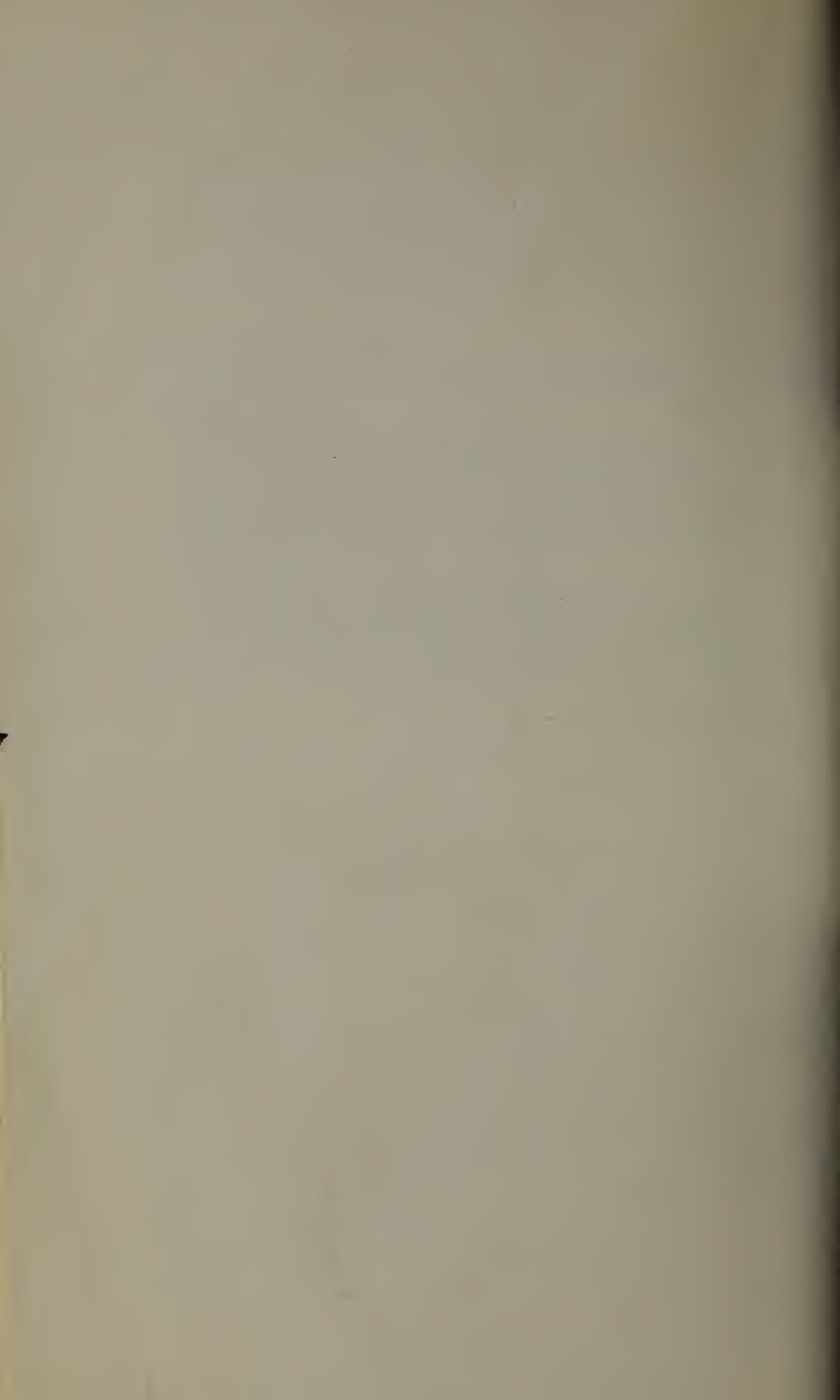
Admission to candidacy does not guarantee the granting of the degree.

Requirements for Graduation

To be recommended for the Doctor of Philosophy degree, a candidate must:

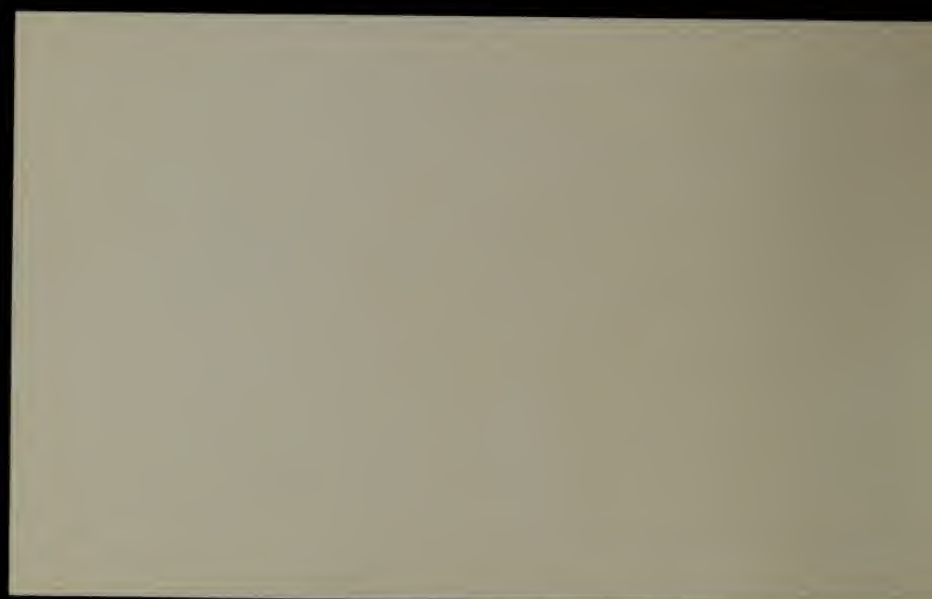
1. Satisfy the residence requirements.
2. Pursue with satisfactory grades an approved program of study, which includes a minimum of 90 credit hours beyond the B.S. At least 45 credit hours must be in formal subjects.
3. Demonstrate satisfactory reading ability in German and one other language.
4. Pass the qualifying examinations for candidacy.
5. Pass the major examinations in the field of concentration.
6. Complete a satisfactory thesis and pass the oral thesis examination.





Bulletin 1961-1962

was never published by LTI, therefore, not included in this volume.



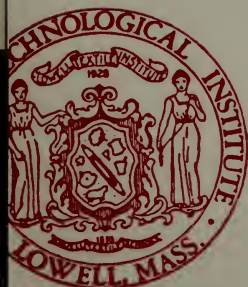
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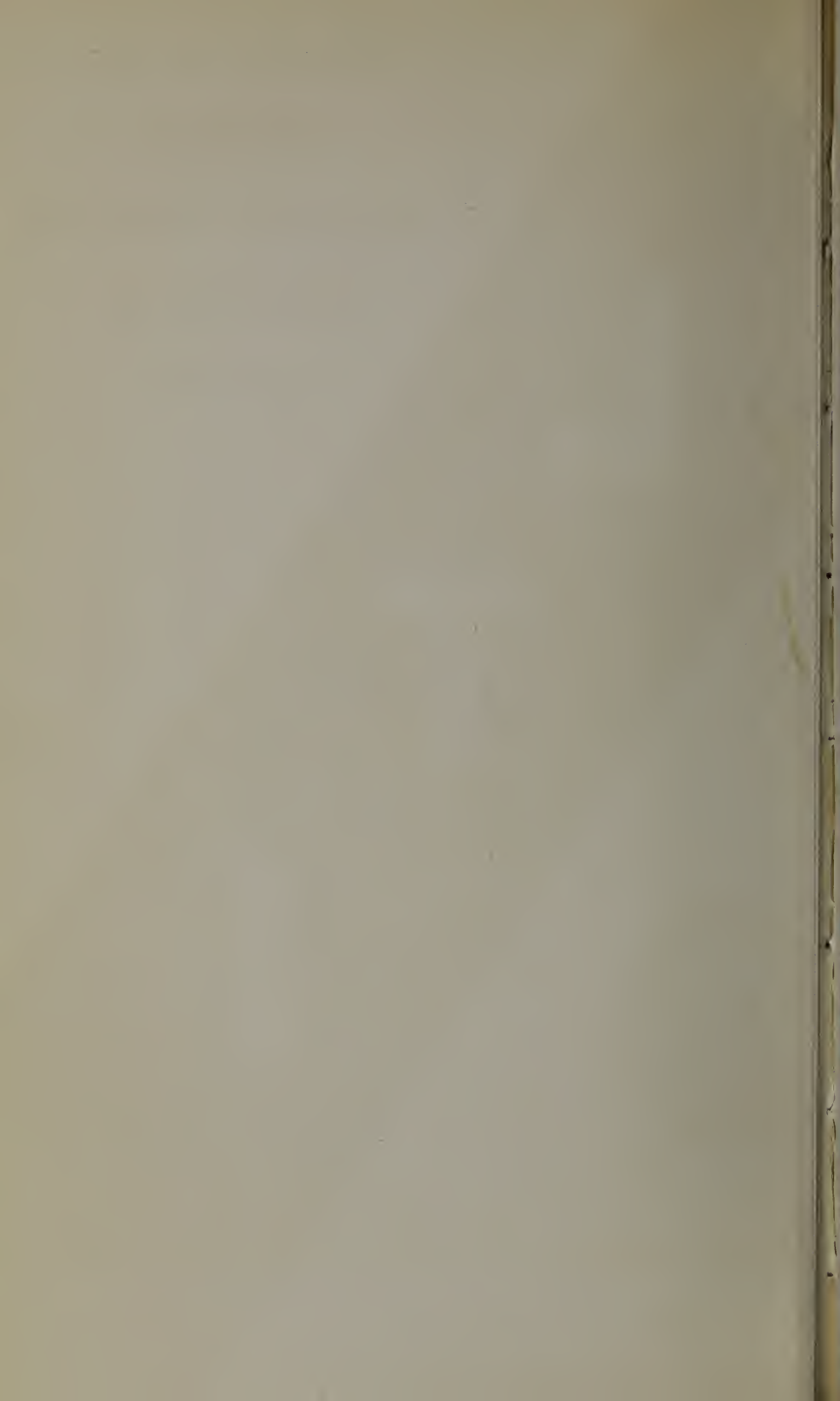
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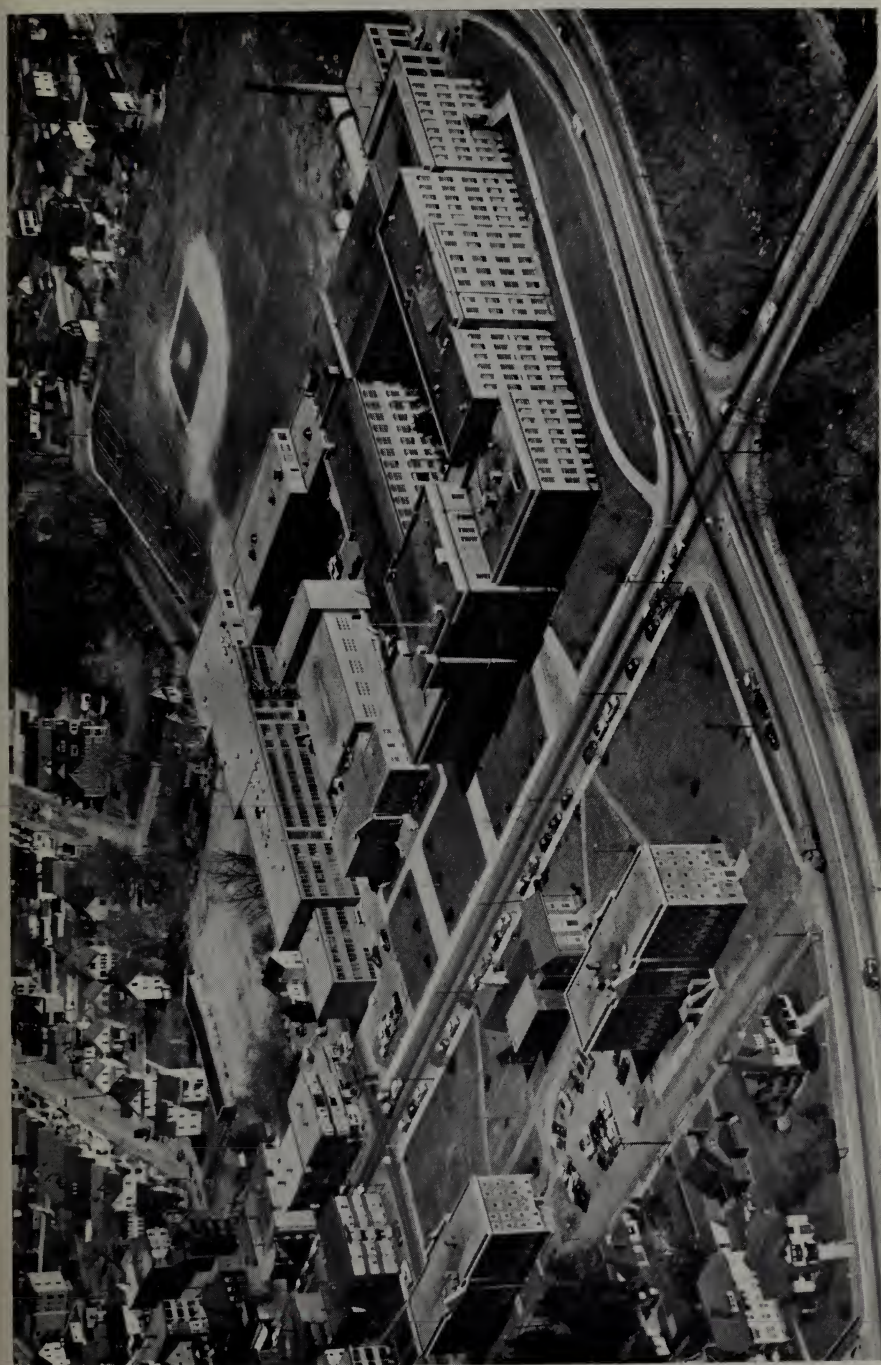
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1962-1963





Aerial View — LTI Campus

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LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Massachusetts

Established 1895

Operated by the Commonwealth of Massachusetts

Engineering and scientific curricula leading to B.S., M.S., and Ph.D. degrees

Member of, or approved by, American Chemical Society, American Council on Education, College Entrance Examination Board, Engineers' Council for Professional Development, New England Association of Colleges and Secondary Schools

Total enrollment—4400

Day Division—1300

Evening Division—2500

Summer School—600

Men and women students from 17 states and 31 countries

Tuition: \$200 for U. S. citizens who are residents of Massachusetts

\$300 for U. S. citizens who are residents of states other than
Massachusetts

\$550 for all others

L.T.I. Research Foundation conducts research and development work for government and industry.

American Association of Textile Chemists and Colorists maintains headquarters and national research laboratories at the Institute.

Office hours: 8:30 A.M.—5:00 P.M., Monday through Friday

The main campus lies between Mass. route 113 and the VFW Highway along the bank of the Merrimack River, one-half mile north of the center of Lowell, 25 miles north of Boston.

Telephone number: Glenview 4-7811 (Area Code 617)

The Lowell Technological Institute Bulletin is published quarterly and consists each year of a Day School Catalogue, an Evening Division Catalogue, and two technical papers.

Entered as second-class matter August 26, 1902, at the post office, Lowell, Mass.
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Act of October 3, 1917, authorized October 21, 1918.

ACADEMIC CALENDAR, 1962-1963

September 10, Monday	Freshman Orientation Week begins. Registration of graduate students begins.
September 13, Thursday	Registration of sophomores.
September 14, Friday	Registration of seniors and juniors.
September 17, Monday	Classes begin.
September 21, Friday	Last day to register for new classes.
October 11, Thursday	Last day to drop classes without penalty.
October 12, Friday	Columbus Day. Institute closed.
November 12, Monday	Veterans Day observance. Institute closed.
November 21, Wednesday, 5 P.M.	Thanksgiving recess begins.
November 26, Monday	Classes resume.
December 17, Monday and December 18, Tuesday	Reading Period.
December 18, Tuesday, 5 P.M.	Christmas recess begins.
January 2, Wednesday	Classes resume.
January 17, Thursday	First-semester examinations begin.
January 23, Wednesday	End of first semester.
January 31, Thursday and February 1, Friday	Registration of all students.
February 4, Monday	Classes begin.
February 11, Monday	Last day to register for new classes.
February 22, Friday	Washington's Birthday. Institute closed.
March 1, Friday	Last day to drop classes without penalty.
April 8, Monday and April 9, Tuesday	Reading Period.
April 9, Tuesday, 5 P.M.	Easter recess begins.
April 15, Monday	Classes resume.
April 19, Friday	Patriots Day. Institute closed.
May 25, Saturday	Second-semester examinations begin.
June 7, Friday	End of second semester.
June 9, Sunday	Baccalaureate and Commencement.

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 A. Edwin Wells, B.T.E., M.Ed., Prof., Mechanical and Textile Engineering
 Albert T. Woidzik, B.S., Asst. Prof., Evening Studies
 Waldo W. Yarnall, B.S., Asst. Prof., in charge of Physical Education and
 Director of Athletics

Professors Emeriti

Hermann H. Bachman
Herbert J. Ball, S.B., B.C.S., Sc.D., Fellow of the Textile Institute (British)
Harry C. Brown, B.S.
William G. Chace, Ph.B., M.S.
Harold C. Chapin, A.B., A.M., Ph.D.
Elmer E. Fickett, B.S., Sc.D.
Russell M. Fox
C. Leonard Glen
Martin J. Hoellrich
James H. Kennedy, Jr., B.T.E., M.S.
Gilbert R. Merrill, B.T.E.

ADMINISTRATIVE ASSIGNMENTS

Admissions Office

Richard W. Ivers, B.A., M.Ed., *Director of Admissions*
Arthur F. Haley, B.S., M.Ed., Ed.D., *Admissions Officer*
Maurice W. Harrison, B.T.E., *Admissions Officer*

Assistant to the President's Office

Kleonike Bentas, *Secretary*

Buildings and Power

George F. Abodeely, LL.B., *Administrator*
Ralph E. Frost, *Chief Engineer*
Joseph A. Nerney, *Maintenance Foreman*

Bursar's Office

Wilfrid J. Brodeur, *Bursar*
Patricia J. Gallagher, *Clerk*
Barbara M. Jaros, *Bookkeeper*
Charles F. Johnson, *Property Officer*
John L. Sayer, *Bookkeeper*
Mary C. Sullivan, *Clerk*

Dean of Faculty's Office

Theresa D. Leblanc, *Secretary*

Dean of Students' Office

Barbara Jean Maccaron, *Secretary*

Division of Chemistry and Applied Chemistry

Rosemary Cambria, *Secretary*
Mona M. Davis, *Secretary*
Ray E. MacAusland, *Chemical Storekeeper*

Division of Evening Studies

Ann V. Lenihan, *Secretary*

Mary E. Perkins, *Secretary*

Division of General Studies

Carole Freeman, *Secretary*

Division of Physics and Engineering Science

Joan Cinq-Mars, *Secretary*

Eleanor M. McKenna, *Secretary*

Leo F. Patenaude, *Electronics Equipment Supervisor*

Graduate School Office

Mary A. Gomes, *Secretary*

Guidance

John J. MacLaughlan, Ph.B., A.M., *Director*

Health Services

Arlene D. Gordon, *R.N.*

(Local physicians and specialists as required)

Libraries

Howard K. Moore, A.B., A.M., Ph.D., *Director*

Joseph V. Kopycinski, B.S., M.S., M.S. in Library Science, *Librarian*

Charles F. Donaldson, *Library Assistant*

Ruth B. Fitzgerald, *Library Assistant*

Mary P. Frascarelli, *Library Assistant*

Eleanor T. Lessard, *Library Assistant*

Vera Boyd Meehan, B.S., *Library Assistant*

Ann V. Pendergast, *Library Assistant*

June E. Traverse, *Library Assistant*

Military Property

William C. Bellegarde

Placement Office

James W. Bell, *Director of Placement*

President's Office

Helen G. Flack, S.B., *Executive Secretary*

Elizabeth P. Kennedy, *Secretary*

Receptionist

Lorraine I. LeDoux

Registrar's Office

Walter M. Drohan, A.B., A.M., *Registrar*

Nora M. MacBrayne, *Secretary*

Catherine P. Ouellette, *Clerk*

Special Services

Earl J. Watt, A.B., A.M., *Coordinator of Special Services*

Barbara A. Browne, A.B., *Director of Information*

Mary A. Gomes, *Secretary*

Summer School

Ernest P. James, B.T.C., M.S., *Director*

GENERAL INFORMATION

History

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry.

In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and in the past decade degree programs have been added in the fields of leather chemistry, paper technology, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, physics, physics and mathematics, nuclear science, nuclear engineering, and industrial management.

In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to the Lowell Technological Institute. The Institute grants Bachelor of Science, Master of Science, and Doctor of Philosophy degrees.

Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

Accreditation

The Institute is a member in the Senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends full accreditation to the curriculum in textile engineering, and the undergraduate chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige in its early field of specialization, textiles, has attracted students annually from approximately 35 other countries.

The Institute accepts both men and women for admission, provided they are qualified graduates of accredited secondary schools. Although the majority of its students are men, the Institute welcomes young women students who recognize the increasing opportunities in industry open to women trained in science.

Campus

The Institute is located 25 miles north of Boston in Lowell, Massachusetts, a city of nearly 100,000, long famous as a textile center and more recently for its increasingly diversified industries. The 18.6-acre campus on the west bank of the Merrimack River includes eleven main buildings, among them the library, an auditorium-administration building, six classroom-laboratory buildings, two residence halls, and a power plant, and ground will be broken in 1962 for a \$4,400,000 nuclear center.

Alumni Memorial Library

The library, dedicated to alumni of the Institute who served in World Wars I and II and the Korean conflict, was erected in 1951 by the Alumni Association through contributions from alumni and friends. Besides a book stack capacity of 80,000 volumes, it contains student activity offices, alumni and placement offices, and houses one of the world's most complete collections of textile books and numerous special collections in the fields of paper, leather, and plastics. It also serves as a depository for U. S. government publications and is available to industrial concerns through its Industrial Corporate Membership program.

Equipment

Total value of the scientific and industrial equipment used in the instructional and research programs of the Institute is approximately \$12,500,000. This equipment ranges from delicate instruments, such as the electron microscope, to full-sized industrial machines and includes complete pilot-plant facilities in all technological areas, paper, plastics, leather, and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Students from other countries are advised to start the application procedure not less than 12 months in advance of the expected date of enrollment.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Director of Admissions.

Application Procedure

A candidate for admission should:

1. Complete the first two pages of the admission application form.
2. Attach a certified check or money order in payment of the application deposit of \$10 (see Student Expenses for explanation).
3. Submit the entire application form to the office of his secondary-school principal, with a request that the office fill out pages 3 and 4 and mail the completed application directly to the Director of Admissions.
4. Make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test which is required of all applicants for admission to the freshman class at the Institute.

Applicants for admission who are in the upper 20% of their high-school class scholastically may be admitted by the Chairman of the Committee on Admissions prior to their completion of entrance examinations.

Late applicants will be specifically advised with respect to entrance examinations by the Director of Admissions.

5. Undergo a complete health examination by his family physician. The physician must return to the Director of Admissions, in duplicate, on forms provided by the Institute a certificate of good health, indicating the date of the examination.

6. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of his place of residence.

All admission records, once submitted, become the property of the Institute and cannot be returned.

7. Make formal application for a scholarship with the Institute, if he desires scholarship aid.

8. Upon receipt of his letter of admission, submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll.

A personal interview with the Director of Admissions is strongly recommended. The Office of Admissions is open Monday through Friday from 8:30 A.M. to 5:00 P.M. throughout the year. *Appointments for interviews should be made in advance.*

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must be a graduate of a secondary school approved by the New England Entrance Certificate Board, the Regents of the State of New York, or a board of equal standing.

2. He must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	$\frac{1}{2}$ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least $15\frac{1}{2}$ units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

In evaluating credits offered for admission, the Institute is guided primarily by the quality of the scholastic record of the applicant and by his promise on grounds of intellect and character. Therefore, an applicant whose preparation has not followed the normal pattern with respect to the accumulation of unit credits should not hesitate to apply for entrance, provided that the quality of his scholarship gives evidence of ability to do college work and provided that he is recommended by his school.

Admission with Advanced Standing

Transfer students must submit transcripts of their college record, a copy of their college catalogue, and letters of honorable dismissal from their college well in advance of their planned transfer date.

Transfer credit is given for courses satisfactorily completed with a grade of C or better which are the equivalent in quality and scope of those given at the Institute. Final decision on transfer credit rests with the appropriate division chairman and the Dean of Students.

Transfer students who have not taken the Scholastic Aptitude Test of the College Entrance Examination Board for matriculation at their previous college may be required to do so. It is the responsibility of the transfer student to ascertain the procedure to be followed from the Admissions Office prior to his acceptance.

Additional advanced credit will not be given a student, once he has matriculated, for courses completed prior to his admission but not at the time of acceptance.

Special Students

Qualified applicants are accepted for specialized work not leading to a degree. Their plan of study should have a clearly defined objective and should not deviate markedly from the regular subject matter and laboratory courses at the Institute. Admission in this status is contingent upon approval by the Committee on Admissions and the division chairmen concerned in the proposed program.

Students from Other Countries

The Institute accepts every year foreign applicants in each class in numbers up to 5% of that class. In all respects, the admission procedure for foreign students is the same as that required of U. S. citizens. They are urged, however, to have the transcript of their secondary-school and/or college records, as well as all other application materials, submitted, *in English, not less than twelve months in advance of the expected date of enrollment.* All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U. S. students.

To facilitate their adjustment to campus life, all male students from other countries are required to live in the Institute's residence halls and are assigned to rooms shared by U. S. students. Students may supply their own towels, sheets, pillowcases, and blankets or may subscribe to a laundry service. Bedding, as well as clothing, should be suitable for a climate in which temperatures normally fall well below the freezing point during the winter months.

STUDENT HOUSING AND SERVICES

Residence Halls

All male students not living at home are required to live in the residence halls on campus unless they are excused in writing by the Dean of Students. Excuses are reviewed at the beginning of each semester and may be cancelled, should conditions warrant.

Application for permission to occupy other living quarters must be made on special blanks available at the Office of the Dean of Students. An application for this purpose must be filed annually by every student desiring off-campus residence. All new students (incoming freshmen, transfer, special, or graduate students) must file before September 1, and all regularly enrolled students must file before June 1, of the year in which off-campus residence is desired.

Permission is accorded in cases where the student lives a reasonable distance from the Institute, where financial hardship would be involved through living in a residence hall, or where the student is a member of a fraternity which maintains a fraternity house. Also considered in granting permission is the academic year of the student (graduate, senior, junior, sophomore, freshman).

Although rooms are furnished by the Institute, students must take care of them. Each student may supply his own sheets, pillowcases, blankets, towels, and personal linens or may subscribe to the laundry service provided to all resident students on a voluntary basis. Each occupant of a room is responsible for damage which may result to furniture or equipment.

Room assignments in residence halls are made for the full academic year. A change of room is not permitted except in rare instances and may be accomplished only after formal application for the change is approved by the Dean of Students.

Rental charge for each residence room is made for the academic year. While the charge covers occupancy during periods when the Institute is in regular session, it may, at the discretion of the Institute, be extended to include vacation periods.

Room assignments are made as equitably as possible and in the order that applications are received. The Dean's Office supplies a list of approved rooming houses where students may reside who are unable to be placed in residence halls.

Students are cautioned to make no legal agreements nor sign residence leases with persons outside the Institute.



Room in Residence Hall



Faculty-Student Conference

Dining Hall

A cafeteria and a snack bar are available in the residence halls, but use of campus dining facilities is not compulsory.

Health Service

The dispensary, in Smith Hall, is in the charge of a registered nurse for eight hours each school day. She is on call 24 hours daily, including weekends. Students receive first-aid treatment at the dispensary and are advised as to the best procedure to take in case of illness. Medical services are available to students 24 hours daily. If a student requires hospitalization, admission is arranged at one of the three excellent modern hospitals in the immediate vicinity of the Institute. Students must bear their own medical fees and hospital charges.

Accident insurance during the academic year is compulsory and is included in the activity and insurance fund. Health insurance also is available, on a voluntary basis, through the Office of the Dean of Students.

Guidance

The guidance program, under the supervision of the Dean of Students' Office, starts with the admissions procedure and continues throughout the freshman year. During registration, a testing program is conducted, results of which are used to supplement the student's scholastic record and his College Entrance Board examinations. During Orientation Week, the freshman attends a series of lectures whose purpose is to help him in his adjustment to college requirements.

Each freshman is assigned by the Director of Guidance to a faculty member who is his primary contact with other phases of the guidance program. This adviser, who is also a freshman instructor and may arrange individual consultations, provides advice and referral help in scholastic, financial, personal, or health problems.

Other phases of the guidance program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sections. In the second semester of the freshman year a series of lectures is offered to help the student to become aware of the curricula at the Institute and to determine what course he should elect for the next three years.

Guidance in the upper classes is generally conducted in scholastic matters by the head of the department concerned and in personal problems by the Director of Guidance.

STUDENT REGULATIONS

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups of students but to provide a pattern so that a large student body may live and work harmoniously together.

A student may be dropped from the rolls whenever it is considered in the best interests of the Institute.

Attendance

All students must attend all classes, although a limited number of absences is permitted. Attendance is taken at all classes. Students charged with unexcused absences, particularly immediately before and after holiday and vacation periods, are subject to disciplinary action.

Disciplinary Action

Disciplinary action may be in the form of censure, restriction, suspension, or dismissal, according to the measure of an offense. Whenever such action is taken, notation of the penalty is made a part of the permanent record of the student.

Classification of Students

The status of "clear" is accorded a student with no deficiencies on his record through his last completed semester provided he maintains a 1.7 cumulative average.

The status of "deficient" is accorded a student if his total cumulative average falls below 1.7, if he is on scholastic probation with an average of less than 1.3, or if at any time he has not cleared a grade of F in a subject.

Grading System

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

A+	4.3	(97-100)	C	2.0	(73-76)
A	4.0	(93-96)	C-	1.7	(70-72)
A-	3.7	(90-92)	D+	1.3	(67-69)
B+	3.3	(87-89)	D	1.0	(63-66)
B	3.0	(83-86)	D-	0.7	(60-62)
B-	2.7	(80-82)	F	0	(below 60)
C+	2.3	(77-79)			

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than

one semester is obtained in the same manner as the computation for the rating of a single semester.

Dean's List

The Dean's List is composed of students who have a semester rating of 3.0 or higher, with no current failures.

Probation

A student is placed on probation when his semester rating is below 1.3. The probationary period covers the entire semester following the issuance of the semester rating which placed the student on probation.

A student on probation may not represent the Institute in any public function and may not hold class or other offices during his term of probation.

A student with a rating of less than 1.3 for two consecutive semesters is dropped from the Institute for at least one semester.

If a student receives a semester rating below 0.7, he is automatically dropped from the Institute without benefit of a probationary period.

Scholastic Reports

Reports of scholastic standing are compiled at the end of each semester, and formal notification of each student's status is made at that time.

REQUIREMENTS FOR GRADUATION

In order to be recommended for the baccalaureate a student must satisfy the following minimum requirements:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in a major subject.
2. Earn a cumulative rating of 1.7 or above for the entire period at the Institute.
3. Pass 80% of the credit hours required for the degree with grades of C or better.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors—graduation with a rating of at least 3.0 but less than 3.3 for the entire period of study at the Institute;

With High Honors—graduation with a rating of 3.3 or higher for the entire period of study at the Institute;

With Highest Honors—graduation as the highest ranking student in the class and with a rating of 3.7 or higher, contingent upon the completion of at least six semesters of work at the Institute.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening Division are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION DEPOSIT..... \$10

This is payable by certified check or money order and is filed with the Director of Admissions at the time of application.

1. If the applicant is accepted for admission and is duly enrolled as a student at the Institute, the entire amount of this deposit is credited toward his tuition charges on the day of registration.
2. If the applicant is not accepted for admission, the entire amount of the deposit is refunded.
3. If the applicant is accepted for admission but does not choose to enroll, no refund is made.
4. If the applicant is accepted for admission but is called to duty in the armed forces of the United States, he is entitled to a refund of the entire amount of the application deposit.
5. The Institute requires the prepayment of 50% of the first semester's tuition within 30 days of the date upon which the applicant is accepted for admission. For Massachusetts residents this amounts to \$50. This prepayment is forfeited if the student fails to register at the Institute. In rare instances, such as sickness which would prevent the applicant from enrolling, this rule may be waived by the Dean of Students.

TUITION

	(per year)
U. S. citizens who are residents of Massachusetts	\$200
U. S. citizens who are residents of states other than Massachusetts	\$300
All others	\$550

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule:

	(per semester)
U. S. citizens who are residents of Massachusetts . .	\$10.00 per cr. hr.
U. S. citizens who are residents of states other than Massachusetts	\$15.00 per cr. hr.
All others	\$27.50 per cr. hr.

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community claimed as legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.
2. The residence of a minor follows that of the parents, unless the minor has been emancipated. A minor student who has been emancipated must also present documentary evidence of emancipation.
3. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.
4. The residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.
5. The residence of a wife follows that of the husband.
6. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.
7. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.
8. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

Note: Wherever mentioned above, the word *residence* means *legal domicile*.

ROTC DEPOSIT \$25

This deposit covers loss of, or damage to, uniforms or equipment used for ROTC instruction and is required of all students enrolled in that program. The entire amount, minus charges, is refunded upon completion of ROTC requirements. If, at any time, the charges against a student exceed the

amount on deposit, he must pay the charges and make an additional deposit of \$25.

ACTIVITY AND INSURANCE FUND..... \$43

Each student enrolled in 10 or more total credit hours must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

RESIDENCE HALLS

The residence hall charge is at the rate of \$550 per room for the academic year, this sum to be divided equally among all occupants of the room (two to four students). One-half of the charge is payable by each occupant at the beginning of each semester.

LATE REGISTRATION FEE..... \$5

A student who does not complete his registration (including the payment of all fees) by the close of the registration period must pay this additional fee.

AUDITING FEE..... \$5/credit hour

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Students.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay \$5 per credit hour to audit a course and must obtain permission from the Dean of Students.

COMMENCEMENT FEE..... \$15

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap and gown, invitations, printing, and any other expenses approved or directed by the President.

OFFICIAL TRANSCRIPT FEE..... \$1/copy

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of \$1 per copy is made for each *additional* transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

All raw stock and yarn furnished to students and all productions of the Institute remain or become its property, except by special arrangement. Each student, however, is allowed to retain specimens of yarn or fabrics that he has produced, if they are mounted and tabulated in accordance with the requirements of the department. Departments may retain such specimens of students' work as they desire.

Laboratory equipment may not be removed from the premises except by special permission.

REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks		Refund Rate
At least	But less than	
0	2.....	80%
2	3.....	60%
3	4.....	40%
4	5.....	20%
5 and over	None

SUMMARY OF EXPENSES PER YEAR

Tuition

U. S. citizens who are residents of Massachusetts.....	\$200
U. S. citizens who are residents of states other than Massachusetts	\$300
All others.....	\$550

Residence halls..... **\$550 per room,**
divided equally among occupants (2 to 4)

Student activity and insurance fund..... **\$ 43**

ROTC deposit..... **\$ 25**

Books, supplies, and related miscellaneous expenses (approximate) **\$100**

FINANCIAL AID

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the scholarships are renewable annually for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are for a specified period of time.

At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Director of Admissions before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for the test, candidates must also make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Albany Felt Company Scholarship

One annual grant of \$500 to a freshman entering the Institute is made by the Albany Felt Company. Each recipient is given an opportunity for summer employment at the company while in college.

Alumni Association Scholarships

The L.T.I. Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is maintained. Funds for these scholarships are derived from the following sources:

Stephen E. Smith Scholarship Fund

James T. Smith Fund

Arthur A. Stewart Memorial Scholarship Fund

Warwick Chemical Foundation in memory of Walter Nowicki

Berkshire Hathaway, Inc. Scholarships

A number of scholarships covering tuition and living expenses for four years are offered in Textile Engineering and Textile Technology by Berkshire Hathaway, Inc., Providence, R. I. Male employees and sons of employees only are eligible. Students interested should contact Berkshire Hathaway, Inc., 704 Hospital Trust Building, Providence, R. I.

Russell L. Brown Scholarship, donated by Davis and Furber Machine Company

This scholarship is open to a student who plans to major in Textile Engineering or Textile Technology. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipend is \$300. Appointments are for one year only but are renewable.

Endicott-Johnson Corporation Scholarship

A scholarship of \$500 a year, renewable under the usual conditions, is open to a student in Leather Chemistry whose residence is in the "Triple Cities" area of Binghamton, Endicott, and Johnson City, N. Y. Preference is given to employees and sons of employees of Endicott-Johnson Corporation.

Joseph Kaplan Scholarship

A \$250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute. The scholarship fund was established by the late Joseph Kaplan.

A. C. Lawrence Leather Company Scholarship

The A. C. Lawrence Leather Company in Peabody, Mass., makes available a \$500 scholarship on a one-year basis to a student in Leather Chemistry. Preference is given to an employee or member of an employee's family or to a resident of a town in which the company operates. If no eligible applicant is available, the award is open to any member of the Department of Leather Chemistry on the basis of merit.

Leather Chemistry Department Scholarships

The Department of Leather Chemistry has funds contributed by industrial firms and trade organizations for scholarships and awards. These scholarships are available to deserving students enrolled in Leather Chemistry who need financial assistance for scholastic purposes.

City of Lowell Scholarships

The City of Lowell has appropriated funds to provide a total of five scholarships every two-year period. They are awarded through competitive examination to residents of the City of Lowell, Mass., who are enrolled

in the freshman class at the Institute. The amount of each scholarship is \$200, which is full tuition, and each is renewable provided satisfactory scholastic grades are maintained.

Commonwealth of Massachusetts Scholarships

Ten scholarships of \$250 each are available annually to young men and women who are residents of the Commonwealth of Massachusetts and who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and the scholarships are renewable under the usual conditions.

McLaurin-Jones Scholarship

This scholarship is awarded annually to a member of the Framingham, Needham, Tantasqua Regional, or Ware, Mass., Netcong, N. J., or Homer, La., high-school graduating class, or to an employee or son of an employee of Ludlow Papers, Inc. (formerly McLaurin-Jones Company) for work in the Paper Technology Department. The \$500 scholarship is renewable from year to year for four years if a satisfactory scholastic record is maintained.

Mohawk Carpet Mills Textile Scholarship

A \$2000 scholarship is open to residents of New York state, preferably employees of the Mohawk Carpet Mills, who have been accepted for enrollment at the Institute and who intend to major in one of the various textile programs. Application must be made to Mohawk Carpet Mills, Inc., Amsterdam, N. Y.

New England Tanners Club Scholarship

This scholarship of \$1000 on a one-year basis is granted to a student in Leather Chemistry by annual vote of the New England Tanners Club. Preference is given to employees of the member companies of the club or to their families. If no eligible applicant is available, the award is open to others on the basis of secondary-school scholastic performance and evidence of potential leadership.

Paper Technology Department Scholarships

Five scholarships, each amounting to \$2000 over the four-year period, are available to incoming freshmen who plan to enroll in the Paper Technology Department. Scholarship holders receive annual stipends of \$500 provided they maintain good academic standing. The grants are donated by interested companies in the paper industry.

Salem Oil & Grease Company Scholarships

Two scholarships of \$500 each are made available every year by the Salem Oil & Grease Company in Salem, Mass., which established the awards as a memorial to the late Harold T. N. Smith, a founder of the company. These are awarded to students enrolled in Leather Chemistry on the basis of scholastic ability and financial need.

**Sylvan I. Stroock Scholarship, donated by
S. Stroock & Co., Inc.**

A \$500 scholarship is awarded each year on the basis of scholarship, financial need, leadership, and promise of success in textile fields from funds established by S. Stroock & Co., Inc.

**H. Webster Thomas Memorial Scholarship,
donated by the Rohm & Haas Corporation**

This scholarship in the amount of \$500 per year is awarded for a four-year period to a student in Leather Chemistry through funds established by the Rohm & Haas Corporation of Philadelphia, Pa.

United Elastic Corporation Scholarships

Scholarships of \$250 are available through the United Elastic Corporation to students in any of the various textile courses. Preference is given to employees or their families, or to residents of communities where plants are located. Especially preferred are native New Englanders. Recipients agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. The scholarships are made for a one-year period and are extended if the performance of recipients during the year is satisfactory. All applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, Lowell, and Littleton, Mass.; West Haven, Conn.; and Stuart, Va.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

AVAILABLE TO UPPERCLASSMEN ONLY

Allied Chemical Corporation Scholarship

This grant of \$500 plus tuition, given by the Allied Chemical Corporation, is awarded to a worthy upperclassman majoring in Textile Chemistry or Textile Engineering.

Arthur Besse Memorial Scholarship

The Arthur Besse Memorial Trust awards a \$500 scholarship each year to a student majoring in textiles and planning to continue in that industry after graduation. The award is based on need, scholarship, and qualities of character and leadership, and the scholarship is renewable if a satisfactory scholastic record is maintained.

Boston Paper Trade Association Scholarships

Two scholarships, each for \$150, are open to sophomores, juniors, and seniors enrolled in Paper Technology who are residents of New England. They are renewable under the usual conditions. Awards are based on scholarship and character.

Dr. Geoffrey R. Broughton Paper Technology Scholarships

Scholarships of \$100 are made at the beginning of each semester to the junior and senior in the Paper Technology Department who have achieved the highest semester averages in the preceding semester. In the 1962-1963 academic year the scholarship will be limited to the senior in the department who has the highest semester rating. These grants are available through contributions of companies in the paper industry.

Chemstrand Corporation Scholarship

The amount of \$500 has been made available by the Chemstrand Corporation for a superior, deserving student enrolled in Textile Engineering.

Ciba Company, Inc. Scholarship

Ciba Company, Inc., awards \$500 each to a senior and a junior in Textile Chemistry. Selection is based upon scholastic prowess.

Foster Grant Scholarship

The Foster Grant Company, Inc. of Leominster, Mass., makes available on a one-year basis a tuition scholarship to a deserving student in Plastics Technology who is a resident of Massachusetts. Preference is given to a sophomore living in the Leominster area; however, if there are no applicants from that area, another candidate may be chosen. Scholarship, personality, and over-all student contribution to extracurricular activities are the general criteria used in selecting the recipient.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of \$75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

Ralph E. Hale Scholarship

A scholarship of \$250 every year is awarded to a student at the completion of his junior year in the Textile Chemistry curriculum. It was established by the Northern New England Section of the American Association of Textile Chemists and Colorists in memory of Ralph E. Hale, 1951 Chairman-elect of the Section and a 1931 graduate of L.T.I.

Interchemical Corporation Scholarships

Four \$250 scholarships have been made available by the Interchemical Corporation of Pawtucket, R. I., to students completing two years of undergraduate work, preferably to majors in Textile Chemistry or allied fields. They are awarded for scholastic achievement, character, and leadership potential.

New England Paper Merchants Association Scholarship

A \$100 scholarship, renewable annually, is open to a sophomore, junior, or senior in Paper Technology who is a resident of New England. It is awarded on the basis of scholarship and character.

Paper Technology Department Scholarships

Five scholarships, each amounting to \$1500 over the three-year period, are available to sophomores enrolled in the Paper Technology curriculum. Scholarship holders receive annual stipends of \$500 provided they maintain good academic standing. The grants are donated by interested companies in the paper industry.

Society of Plastics Engineers Scholarships

Two \$500 scholarships, given by the Eastern New England Section of the Society of Plastics Engineers, Inc., are available to deserving students in Plastics Technology.

United States Rubber Company Foundation Scholarship

This scholarship of \$600 is awarded to a junior or senior displaying leadership, capacity for higher education, and need, and giving evidence of interest in a career in industry. The recipient assumes a moral obligation to repay 25% to the scholarship fund.

Jacob Ziskind Memorial Scholarship Fund

This fund was established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes. Scholarships are awarded annually and are renewable under the usual conditions. They include tuition, books, supplies, and related expenses. Eligible for these scholarships are seniors, juniors, and sophomores who have demonstrated high scholarship, financial need, and qualities of good character and leadership. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

FELLOWSHIPS

Teaching Fellowships

A limited number of part-time instructorships are available to qualified students working toward a graduate degree. Stipends range from \$1500 to approximately \$2500, depending on the nature of the appointment, and reappointment in succeeding years is contingent upon satisfactory

performance of duties. Appointees are expected to carry up to a half-time teaching load primarily involving supervision of undergraduate laboratories and review sections. Application forms may be obtained from, and must be filed prior to April 30 with, the Director of the Graduate School.

Research Fellowships

A few research fellowships are available to qualified students through industrial grants. Appointees are expected to devote full time to study and research. Application should be made at the time of applying for admission to the Graduate School and prior to April 30. Appointments are made about June 1 for the next academic year.

The following research fellowships are available to graduate students in Chemistry and are usually awarded to students in the final stages of the doctoral program:

Allied Chemical Corporation Fellowships

Stipend \$2200. Tuition and fees included.

Research Corporation Fellowships

Stipend \$2200. Tuition and fees not included.

Union Carbide Corporation—Silicones Division

Stipend \$2200. Tuition and fees not included.

National Science Foundation Cooperative Graduate Fellowships

The Institute is a participant in the National Science Foundation's Cooperative Graduate Fellowship Program. These fellowships are awarded on the basis of ability. Candidates must be citizens of the United States on or before March 1 following the submission of their applications and must be admitted to full graduate status by the Institute prior to beginning their fellowship tenures.

The stipend provided by the NSF for Cooperative Graduate Fellows is \$2200-\$3000 for those on a tenure of 12 months and \$1650-\$2250 for those on a tenure of nine months. In addition to the stipend, the NSF pays all tuition and fees to the Institute.

One of the requirements for making application for an NSF Fellowship is to take the Educational Testing Service Graduate Record Examinations (Aptitude Test and one Advanced Test in the area of specialization). Because the deadline for making application for the fellowships is in early November, it is important to make arrangements to take these tests early.

Textile Salesmen's Association of New York Fellowship

A graduate fellowship in textiles is awarded by the Textile Salesmen's Association of New York, based on academic accomplishment and demonstrated ability. The award is limited to full-time students working toward the M.S. degree in Textile Technology who plan to continue working in the field of textiles in this country after graduation.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of \$10 per quarter the first year and \$20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

National Defense Education Loans

The National Defense Education Act offers loans up to \$1000 to needy students. Repayment begins one year after graduation, unless military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3%, beginning with the first payment. Repayments may be made over a 10-year period. A 50% forgiveness clause is included for students who enter the field of elementary- or secondary-school teaching for a period of five years.

Geigy Loans

Geigy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, Textile Chemistry, Paper Technology, or Leather Chemistry. The fund operates under the same conditions as the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

AWARDS

Awards are made annually at an Honors Convocation conducted by the Scholarship and Awards Committee. A few awards are made at Commencement.

American Association of Textile Chemists and Colorists Book Prize. This is awarded to the outstanding graduating senior in the Textile Chemistry course and includes a junior membership for one year in the A.A.T.C.C. The recipient is recommended by the Division of Chemistry and Applied Chemistry. The academic standing of the candidate is an important factor in the decision.

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, sponsored by the Student Council, is given to the member of the senior class who has made the greatest extracurricular contribution to the Institute during his four years of college. The evaluating committee is composed of faculty and administrative personnel selected by the Dean of Students.

Barnett D. Gordon Award. An award of \$250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, a member of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of \$100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New England Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Technology selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering or Textile Technology who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry or Textile Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in chemistry subjects.

Phi Psi Award. This award is given to a member of the graduating class who is outstanding in scholastic attainment, leadership, initiative, personality, loyalty, and courtesy.

President's Medal. This award is made to the student who is graduated *With Highest Honors* for the most distinguished academic record in his class.

Textile Veterans Association Honor Award. A bronze medallion is given to an outstanding graduating student in a textile course on the basis

of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

In addition to the above, a number of other awards are available to AFROTC cadets only. Among them are the Thomas F. Costello Trophy, the Trustees' Medal, and the Alumni Medal.

EMPLOYMENT

No formal part-time or summer placement services are provided by the Institute. However, the Placement Office does attempt to fill all requests originating in industry for this type of employment.

OTHER ASSISTANCE FOR MASSACHUSETTS RESIDENTS ONLY

Board of Educational Assistance Scholarships

These scholarships for one-quarter, one-half, or full tuition are available both to freshmen and to upperclassmen. For full information write to

Executive Secretary
Board of Educational Assistance
200 Newbury Street
Boston 16, Mass.

Massachusetts Scholarship Foundation Scholarships

Awards ranging from \$200 to \$800 are made for the freshman year only by the Massachusetts Scholarship Foundation. For further information address

Massachusetts Scholarship Foundation
Committee on Awards
1746 Cambridge Street
Cambridge 38, Mass.

Higher Education Loan Plan

Under this HELP plan, students beyond the freshman year may obtain bank loans up to \$500 a year upon especially favorable terms. More specific information is available from

Massachusetts Higher Education
Assistance Corporation
1137 Statler Building
Boston 16, Mass.



Sophomores Initiate Freshmen



Between Classes

PLACEMENT

Industrial Training Program

The Placement Office with the assistance of industry endeavors to place qualified underclassmen during summer vacation periods in industries of particular interest to the individual. These training opportunities are open to all students who have completed their sophomore year, except those on scholastic or disciplinary probation.

Objectives of the undergraduate Industrial Training Program are to supply essential industrial experience to the undergraduate, to provide the experience in human engineering only obtained in industry, to enable industry to preview individual students, and to further the liaison between the Institute and industry.

Placement Service

The Placement Office maintains active contacts with many industrial firms throughout the country in each of the fields of concentration presented at the Institute. A complete file of opportunities and data on the various industries and companies is available in the Placement Office to members of the graduating class.

The office arranges for representatives from industrial firms to interview students on campus. In a series of seminars speakers outline the opportunities in particular industries and various positions within the companies.

The office also aids industry in the difficult task of locating experienced personnel and assists alumni to establish new connections. The Placement Office cannot give any graduate a guarantee of employment; however, practically all seniors are placed prior to Commencement every year. No official part-time placement program is in operation because of the heavy academic schedule.

COOPERATIVE PLAN

Massachusetts Institute of Technology

Lowell Technological Institute

A cooperative arrangement between Lowell Technological Institute and Massachusetts Institute of Technology includes the following major provisions:

1. The mutual use of the technological and research facilities for graduate and undergraduate theses;
2. The mutual use of certain library facilities;
3. The opportunity for students at each institute to supplement their programs by pursuing studies at the other institute;
4. The formation of joint seminars and the interchange of staff members for special lectures.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Memorial Library, the Research Foundation, and the Summer School program, the college provides such special services to industry and to the community as the following:

Industrial seminars and conferences;

Guidance work in the high schools;

Consultive opportunities with the faculty;

Collaboration with the Agency for International Development of the government in its foreign aid program;

Special radio and television programs, such as Science Countdown on Boston station WBZ-TV.

For information relative to these programs, address the Coordinator of Special Services at the Institute.

SUMMER SESSION

The Summer Session is designed primarily to serve three principal areas of interest: Professional Advancement Courses for industrial personnel; Undergraduate Credit Courses for college students with course deficiencies; and Precollege Refresher Courses for incoming freshmen at L.T.I.

The industry-sponsored professional advancement program comprises a series of specialized, intensive, one- to three-week courses in textiles, paper, leather and other areas. The six-week undergraduate credit program stresses fundamental courses in college mathematics, physics, chemistry, English, economics, and foreign languages.

Precollege Refresher Courses

The Precollege Refresher Program is especially designed to articulate the high-school training of prospective L.T.I. students with the more intensive college-level studies in basic mathematics, physics, chemistry, and English. The noncredit refresher courses are offered both in a six-week and a four-week session in order to provide adequate coverage for a number of minor deficiencies in the high-school background.

For further information on the Summer Session, write to the Director of Summer School.

EVENING DIVISION

The Evening Division offers five-year associate degree courses in chemistry and leather chemistry, in paper, plastics, and rubber technology, and in electrical (electronics or power options), industrial, and mechanical engineering. It also offers a program of certificate courses in science, technology, engineering, and general studies. These courses are designed to fit the needs of the community, particularly of those people engaged in industry who wish to further their education.

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. For further information, write to the Director of the Evening Division.

RESEARCH FOUNDATION

The Lowell Technological Institute Research Foundation is a nonprofit organization authorized under the laws of the Commonwealth of Massachusetts. It was established for the purpose of encouraging and administering research sponsored by industry and government at the Lowell Technological Institute.

Its research projects benefit the educational program of the Institute by enabling both faculty and students to keep abreast of current developments in their respective fields and to develop further their capabilities.

The scientists and engineers of the Foundation's permanent personnel, together with the faculty of the Institute, constitute a staff available for research, development, and testing in the fields of chemistry, electronics, engineering, leather, management, paper, plastics, and physics.

The Research Foundation has its own specialized laboratories and field stations where research ranging from chemical modification of textile fibers to studies of the ionosphere and thermal radiation is performed. The Foundation also uses in its programs the entire facilities of the Institute. These facilities not only include the usual research tools found in a university or industrial laboratory but also include, in the areas of leather, paper, plastics, and textiles, full-scale and pilot-plant equipment for specialized studies. It is probably the only research organization in the world having at its disposal fully equipped laboratories for processing all types of fibers by all the common manufacturing systems into a finished fabric.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, publishes the official alumni bulletin and the alumni directory, aids student organizations, and conducts its annual business meeting and reunion in the spring of each year. All students who have completed satisfactorily at least one year of the day curriculum are eligible for active membership, and only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership, Scroll, and Citation may be awarded by the Board of Directors to any person who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to Associate Membership by the Board of Directors. The Honorary Award, Scroll, and Citation may be awarded by the Board of Directors to any active member of the Alumni Association who has made outstanding contribution to the arts or sciences.

Communications should be addressed to Professor A. Edwin Wells, Executive Secretary, Alumni Office, Lowell Technological Institute.

Officers

Kalman Kobrin, '44, *President*

Harold L. Peckham, '17, *First Vice President*

G. Frederic Wagner, '38, *Second Vice President and Chairman of the Fund Council*

A. Edwin Wells, '20, *Clerk, Treasurer, and Executive Secretary*

J. Frederic Burt, '31, *Assistant Executive Secretary*

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four officers elected by the student body, the president of each undergraduate class, and one representative from each of the classes. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee.

Athletics

The Athletic Association promotes an extensive varsity and intramural sports program. Varsity sports are soccer, basketball, and baseball, and competition is mainly with college teams in the northeast section of the country. Golf and tennis teams also compete regularly with other colleges in the area. Intramural sports competition among classes, residence hall students, and fraternities is carried on throughout the year. All students are members of the Association and receive free admission to all inter-collegiate contests played at home.

Audio-Visual Society

Objectives of the Audio-Visual Society, composed of students and faculty members interested in this field, are to build and maintain a library of records, recorded tapes, and films, to record special events, and to present various types of audio-visual programs.

Auf Deutsch, Bitte

Informal German conversation marks all meetings of Auf Deutsch, Bitte whose purpose is to foster an understanding of the language, customs, and culture of the German people. Films, music, lectures, and personal anecdotes are featured, and coalition with German clubs of other universities is encouraged.

Band

The AFROTC Band includes cadets who are musicians or who wish to learn to play a band instrument. Besides providing music for AFROTC ceremonies, the band participates in various college and civic programs.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Circle K

The Circle K Club is the student chapter of Kiwanis. In addition to performing many services in the public interest, its members assist the administration in the freshman orientation program each year and provide tutorial help to freshmen.

Dormitory Council

The Dormitory Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a liaison between residents and the administration to maintain proper deportment and living conditions.

Drill Team

The AFROTC Drill Team is open to all cadets who desire to become proficient in precision drill. Exhibitions are presented at various functions throughout the academic year. The team competes in the annual spring New England Colleges Championship Drill Meet.

Duplicate Bridge League

This club, open to students and faculty members interested in duplicate bridge, conducts 10 or more playing sessions each year to determine the champion team. Student members also participate in the annual national Intercollegiate Duplicate Bridge Tournament.

Fraternities

Four fraternities—Delta Kappa Phi, Omicron Pi, Phi Psi, and Pi Lambda Phi—have their own houses to provide centers for social life off campus. Three are national fraternity affiliates. The Interfraternity Council fosters the common interests of the four and sponsors interfraternity social and athletic events.

General Vandenberg Air Society

Purpose of the General Vandenberg Air Society is to unite selected advanced AFROTC cadets by a fraternal bond in order to further the mission and traditions of the Air Force. The society provides a variety of social affairs and air space exhibits during the academic year. The Military Week End, annual highlight of the society's program, features a colorful drill ceremony and has as its climax the formal Military Ball at which new members are accepted into the society.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to adjust to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Nucleus

The Nucleus limits membership to 15 student leaders of all major activities on campus. High scholastic rating also is a requisite for active participation. The organization is primarily a discussion group.

Pickout

The Pickout is the college yearbook. Its staff is wholly responsible for the editorial, graphic, and business problems involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students and guest speakers present technical papers and lectures:

- American Association of Textile Chemists and Colorists, Student Chapter
- American Institute of Physics, Student Section
- American Society of Mechanical Engineers, Student Chapter
- American Society of Tool and Manufacturing Engineers, Student Chapter
- Chemistry Club
- Industrial Management Society
- Institute of Radio Engineers, Student Chapter
- Leather Chemistry Society
- Paper Technology Society
- Society of Plastics Engineers, Student Chapter
- Textile Society

Radio Station

WLTI is an all-student enterprise built and maintained by members of the LTI Broadcasting Society. Programs are transmitted by carrier current from the studio to the various campus buildings. By selling air time to local merchants, the station is self-supporting. Its members learn business practices as well as broadcasting and other radio techniques.

Religious Groups

Hillel. The Hillel Counsellorship provides social, cultural, and religious programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship. Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Newman Club. The Newman Club conducts programs of a social and religious nature for Catholic students at the Institute and at Lowell State College.

Phanar Club. This is composed of Greek Orthodox students from Lowell State College and L.T.I.

Rifle Team

The AFROTC Rifle Team, chartered by the National Rifle Association, is open to all cadets. NRA-qualified members offer the instruction and training necessary for intercollegiate competition. Major matches of each year are the William Randolph Hearst Trophy Match and the Secretary of the Air Force Match.

Sorority

Phi Sigma Rho, the campus sorority, provides a center for the social life and association of the young women enrolled at the Institute.

Tau Epsilon Sigma

Membership in Tau Epsilon Sigma, the scholastic honor society at the Institute, is open to seniors and juniors who are elected on the basis of outstanding scholastic achievement and character.

Tech Alpine Club

Activities of the Alpine Club include mountaineering and hiking trips.

T.O.C.

The Tech Orientation Committee has as its special function the introduction of the new student to college life. T.O.C. plans a week-long series of activities for entering freshmen during the orientation period to enable them to meet one another and to realize their responsibilities to their college.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

The Text

The Text, the campus newspaper, is prepared and edited by students. The bi-weekly publication offers excellent journalistic and business experience to those who work on its staff.

Varsity Club

The Varsity Club is composed of students who have earned letters in the intercollegiate sports, baseball, basketball, golf, soccer, and tennis. Its purpose is to give academic help to athletes and to foster a lasting friendship among the men participating in athletics.

UNDERGRADUATE PROGRAMS

Eleven fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science. These fields are:

Chemical Engineering	Nuclear Science
Chemistry	Paper Technology
Electrical Engineering	Physics
Industrial Management	Plastics Technology
Mechanical Engineering	Textile Engineering
Nuclear Engineering	

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

The Elective System

In all curricula an opportunity is afforded the student to elect subjects in addition to those required for graduation. These electives fall into two categories: technical electives and general electives.

Technical electives give the student a chance to broaden his professional knowledge by taking subjects allied to his main interest or to further his knowledge of a particular phase by taking additional work therein.

General electives are to be selected from the following subjects. At least two electives must be chosen in the social sciences (SS) and two in languages and literature (LL).

EC	201	Economics I	(3-0)3
EC	202	Economics II	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
LL	233	Comparative Literature	(3-0)3
LL	234	Shakespeare	(3-0)3
*LL	261-262	Elementary Technical German	(3-0) (3-0)6
*LL	263-264	Elementary Technical French	(3-0) (3-0)6
*LL	265-266	Elementary Technical Russian	(3-0) (3-0)6
*LL	361-362	Intermediate Technical German	(3-0) (3-0)6
*LL	365-366	Intermediate Russian	(3-0) (3-0)6
LL	367-368	Literary and Conversational German	(3-0) (3-0)6
LL	369-370	Intermediate Literary Russian	(3-0) (3-0)6
LL	467	Advanced Seminar in Literary German	(3-0)3
LL	468	Advanced Seminar in Literary German	(3-0)3
LL	471	The Modern American Novel	(3-0)3
LL	472	The Modern British Novel	(3-0)3
LL	473	World Drama	(3-0)3
LL	474	Modern Drama	(3-0)3
LL	482	The American Short Story	(3-0)3
SS	223-224	The United States Since 1865	(2-0) (2-0)4
SS	226	Europe Since 1914	(3-0)3
SS	301	The Government of the United States	(3-0)3
SS	303	Psychology I	(3-0)3
SS	304	Psychology II	(3-0)3
SS	305 or 306	Sociology	(3-0)3
SS	371 or 372	American Civilization to 1865	(3-0)3
SS	459 or 460	International Relations	(3-0)3
SS	470	Comparative Modern Governments	(3-0)3
SS	472	Foreign Policy of the United States Since 1775	(3-0)3
SS	477 or 478	Twentieth-Century Russia	(3-0)3
SS	479 or 480	The Far East Since 1900	(3-0)3
SS	481	The Greeks and Western Civilization	(3-0)3
SS	482	The Romans and Western Civilization	(3-0)3

*These subjects are not accepted for credit, except as an overload, in Chemistry, Chemical Engineering, Electrical Engineering, Mechanical Engineering, Nuclear Engineering, and Textile Engineering.

The Air Force ROTC Program

By vote of the Board of Trustees, all able-bodied nonveteran male citizens enrolled at the Institute must satisfactorily complete two years of Air Force Reserve Officers Training courses (freshman and sophomore years) before receiving a Bachelor of Science degree.

Cadets who satisfactorily complete the Basic Course (the first two years) may apply for the Advanced Course (the last two years), subject to the approval of the Professor of Air Science.

Uniforms and all equipment and textbooks required for ROTC work are supplied by the United States Air Force. Students in the advanced course receive the standard cash payment allowed by the Air Force in lieu of subsistence.

Students who successfully complete the Advanced Course are commissioned as second lieutenants in the United States Air Force Reserve. Those who qualify receive further training after commissioning in scientific skills, pilot or navigator training, meteorology, and administration. Outstanding seniors who are designated Distinguished Military Graduates may compete for regular commissions and postgraduate education assignments.

BASIC COURSE

Freshman Year	First Semester	—AS	101	Foundations of Aerospace Power I (0-2)0
	Second Semester	—AS	102	Foundations of Aerospace Power II (2-2)2
Sophomore Year	First Semester	—AS	201	Fundamentals of Aerospace Weapon Systems I (2-2)2
	Second semester	—AS	202	Fundamentals of Aerospace Weapon Systems II (0-2)0

ADVANCED COURSE

Junior Year	First Semester	—AS	301	Air Force Officer Development I (4-2)2
	Second Semester	—AS	302	Air Force Officer Development II (2-2)1
		SS	306	Sociology (3-0)3
Senior Year	First Semester	—AS	401	Global Relations I (2-2)1
		SS	403	Foundations of National Power (3-0)3
	Second Semester	—AS	402	Global Relations II (1-2)½
		SS	460	International Relations (3-0)3

A description of these subjects may be found in the section beginning on page 81.

Subjects required in the AFROTC program in the junior and senior years may be substituted for General Electives in all curricula unless otherwise specified.

Summer Camp

Each cadet enrolled in the Advanced Course is required to supplement his training by attending a summer camp of approximately four weeks duration, usually during the summer preceding his senior year. This encampment is held at one of several combat operational air bases where cadets have the opportunity to observe, fly, and live with career personnel. Transportation from the legal residence of the cadet to the camp and return, uniforms, food, lodging, and medical and dental care are provided by the Air Force, and in addition, the cadet receives the pay of a basic airman.

Field Trips

Periodically, the Department of Air Science conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

Flight Instruction

The flight instruction program, designed for seniors in the Advanced Course who plan to enter Air Force pilot training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio, and weather. The flying phase consists of 36.5 hours of flight instruction at government expense.

Veterans

Any veteran who qualifies for and completes successfully the Advanced Course is commissioned a second lieutenant in the Air Force Reserve. Under present Air Force regulations, there is no requirement for an active duty tour; however, a veteran AFROTC graduate may apply for active duty as an officer. The Professor of Air Science may waive, in consideration of military service, portions of the basic course which cannot be completed prior to entrance into the advanced course.

Contribution to Student Life

Besides the military and academic phases of its program, the Department of Air Science sponsors various extracurricular activities which are designed to produce a well-rounded cadet. These include the Vandenberg Air Society, the Rifle Team, the Drill Team, and the Band.

Cadet Decorations and Awards

A number of medals are awarded to selected cadets and cadet officers at a special parade and review held each spring. These include the Thomas F. Costello Trophy, the Alumni Medal, the Convair Cadet Award, the *Chicago Tribune* Awards, the Armed Forces Communications and Electronics Association Award, the Sons of the American Revolution ROTC Award, the Trustees' Medal, the Reserve Officer Association Medal, the Air Force Association Medal, and the Vandenberg Cup.

In addition, the Department of Air Science confers several medals and awards for outstanding performance in various fields, among them the Distinguished Military Cadet Awards.

Distinguished Military Graduate Awards are given to outstanding graduates, based on four years of over-all academic and military achievement. A recipient of this award may apply for a regular commission as second lieutenant in the United States Air Force.

The Freshman Program

ORIENTATION

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating the adjustment of the new student to his physical, social, and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Industrial Management* take the following subjects:

First Semester

†AS	101	Foundations of Aerospace Power I	(0-2)0
CH	101	General Chemistry	(4-3)4
LL	111	English I	(3-0)3
MA	107	Calculus and Analytic Geometry	(4-0)4
ME	101	Engineering Graphics	(1-2)1
PH	103	Physics	(4-1)4
Total credit hours			16

Second Semester

†AS	102	Foundations of Aerospace Power II	(2-2)2
CH	102	General Chemistry	(4-3)4
LL	112	English II	(3-0)3
MA	108	Calculus and Analytic Geometry	(5-0)5
ME	102	Engineering Graphics	(1-2)1
PH	104	Physics	(4-2)4
Total credit hours			19

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education for the whole freshman year. This subject meets one hour per week for AFROTC students and two hours per week for all others. It carries no academic credit.

*See the Industrial Management curriculum on page 62.

†Required of all able-bodied, nonveteran male citizens. See page 51.

‡Required of all able-bodied, nonveteran male citizens. Other students must take in its place SS 102, Foundations of National Power (2-0)2.

Chemical Engineering

The Chemical Engineering curriculum provides training in the fundamentals of unit operations, thermodynamics, and industrial chemistry and in addition includes a thorough background in supporting basic science, engineering science, and mathematics.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
Total credit hours			19

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
CH	202	Organic Chemistry	(3-3)4
CHE	202	Introduction to Chemical Engineering	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(4-2)4
Total credit hours			17

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
CHE	301	Industrial Stoichiometry	(3-0)3
EC	201	Economics I	(3-0)3
*LL	213	Introduction to English Literature	(3-0)3
ME	315	Applied Mechanics	(3-0)3
ME	341	Thermodynamics	(3-0)3
Total credit hours			19

*ROTC students will substitute AS 301 (4-2)2.

Second Semester

CH	332	Physical Chemistry	(3-3)4
CHE	304	Chemical Engineering	(4-0)4
CHE	312	Chemical Engineering Thermodynamics	(3-0)3
EC	202	Economics II	(3-0)3
ME	372	Strength of Materials	(3-0)3
		General Elective	(3-0)3
Total credit hours			20

SENIOR YEAR

First Semester

CHE 405	Chemical Engineering	(4-0)4
CHE 407	Industrial Chemistry	(3-0)3
CHE 411	Chemical Engineering Laboratory	(0-6)2
	General Elective	(3-0)3
	Two Technical Electives	<u>6</u>
	Total credit hours	18

Second Semester

CH 334	Colloid Chemistry	(3-0)3
CHE 410	Plant Design	(3-0)3
CHE 412	Chemical Engineering Laboratory	(0-6)2
	General Elective	(3-0)3
	Two Technical Electives	<u>6</u>
	Total credit hours	17



Air Force ROTC Band



Freshman Chemists

Chemistry

The curriculum in Chemistry is designed to provide a thorough integrated knowledge and familiarity with the basic techniques in chemistry and in the related sciences of mathematics and physics, supplemented by a background in the humanities and social sciences. Graduates are prepared either for further training at the graduate level or for a professional career in chemistry.

The curriculum has been approved by the Committee on Professional Training of the American Chemical Society, and subject selection and credits are designed to meet recommended standards. An approved program of study must include at least eighteen credits of humanities-social studies electives to be selected from the list of recommended general elective subjects. Students satisfactorily completing such an approved program are so listed with the ACS.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
Total credit hours			19
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
CH	202	Organic Chemistry	(3-3)4
CH	206	Qualitative Analysis	(2-6)4
MA	206	Differential Equations	(3-0)3
or			(3-0)3
MA	384	Statistical Methods	(4-2)4
PH	206	Physics	(4-2)4
		General Elective	(3-0)3
Total credit hours			18

JUNIOR YEAR

First Semester

CH	321	Organic Chemistry Laboratory II	(0-6)2
CH	331	Physical Chemistry	(3-3)4
EC	201	Economics I	(3-0)3
LL	261	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
Total credit hours			18

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	342	Organic Qualitative Analysis	(1-6)3
EC	202	Economics II	(3-0)3
LL	262	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
			<hr/>
Total credit hours			19

SENIOR YEAR

First Semester

CH	411	Advanced Quantitative Analysis	(2-4)3
CH	423 or 431 or 443	Advanced Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective	3
			<hr/>
Total credit hours			15

Second Semester

CH	424 or 432 or 444	Advanced Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Two Technical Electives	6
			<hr/>
Total credit hours			15

Recommended Technical Electives for Juniors and Seniors: CH 334, 481; CHE 301, 302; PH 358, 362, 544, 548. For Seniors only: CH 403-404, 408 and/or 409, 423-424, 431-432, and 443-444. Seniors are especially advised to include CH 406 (3-0)3 as a technical elective in the second semester.

Electrical Engineering

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering with emphasis in electronics.

Students are given a thorough grounding in electrical science and engineering, together with an intensive training in mathematics and physics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture demonstrations in the classroom.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	201	Economics I	(3-0)3
EE	201	Fundamentals of Electrical Engineering I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total credit hours			19

*Alternate:	SS 223, The United States Since 1865	(2-0)2
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Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	202	Economics II	(3-0)3
EE	202	Fundamentals of Electrical Engineering II	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	206	Physics	(4-2)4
Total credit hours			17

JUNIOR YEAR

First Semester

EE	301	Electronics I	(4-6)6
EE	303	Electromagnetics	(3-0)3
*LL	213	Introduction to English Literature	(3-0)3
MA	311	Engineering Mathematics	(4-0)4
ME	341	Thermodynamics	(3-0)3
Total credit hours			19

Second Semester

EE	302	Electronics II	(6-6)8
EE	304	Electromagnetics	(3-0)3
*LL	214	Introduction to American Literature	(3-0)3
MA	312	Engineering Mathematics	(4-0)4
Total credit hours			18

*ROTC students will substitute AS 301-302 (4-2)2 (2-2)1 and SS 306, Sociology (3-0)3.

SENIOR YEAR

First Semester

EE	401	Feedback Control Systems and Their Components	(4-0)4
		General Elective	(3-0)3
		Technical Electives to total at least 10 credit hours	
		Minimum total credit hours	17

Technical Electives

EE	403	Microwave Electronics	(3-0)3
EE	405	Communication Electronics	(3-0)3
EE	407	Pulse and Digital Circuits	(3-0)3
EE	409	Solid State Physical Electronics	(3-0)3
EE	411	Logical Design of Digital Computers	(3-0)3
EE	413	Control Systems Engineering	(3-0)3
EE	423	Coherence Theory and Antennas	(3-0)3
EE	425	Electronics III	(3-4)5
EE	427	Transistor Electronics	(3-4)5

Second Semester

EE	402	Feedback Control Systems and Their Components	(3-3)4
		General Elective	(3-0)3
		Technical Electives to total at least 9 credit hours	
		Minimum total credit hours	16

Technical Electives

EE	404	Microwave Electronics	(3-0)3
EE	406	Communication Electronics	(3-0)3
EE	408	Pulse and Digital Circuits	(3-0)3
EE	410	Solid State Physical Electronics	(3-0)3
EE	412	Logical Design of Digital Computers	(3-0)3
EE	414	Control System Engineering	(3-0)3
EE	424	Coherence Theory and Antennas	(3-0)3
EE	426	Electronics IV	(3-0)3
EE	428	Transistor Electronics	(3-4)5
EE	434	Principles of Analog Computation	(1-3)2

Industrial Management

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide the student with a foundation in science and engineering, in the humanities, and in the social sciences. In addition, the various aspects of management—business organization, production, distribution, accounting, and finance—are studied. The student extends his knowledge of mathematics to include statistics. He is also introduced to the newer research methods, including operations research, linear programming, and game theory. A graduate in this program can expect to find employment as a specialist in accounting, procurement, administration, technical sales, or personnel management.

FRESHMAN YEAR

First Semester

AS	101	Foundations of Aerospace Power I	(0-2)0
CH	101	General Chemistry	(4-3)4
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	107	Calculus and Analytic Geometry	(4-0)4
ME	101	Engineering Graphics	(1-2)1
Total credit hours			15

Second Semester

*AS	102	Foundations of Aerospace Power II	(2-2)2
CH	102	General Chemistry	(4-3)4
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	108	Calculus and Analytic Geometry	(5-0)5
ME	102	Engineering Graphics	(1-2)1
Total credit hours			18

*Alternate: SS 102, Foundations of National Power (2-0)2

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	211	Economic Statistics I	(3-0)3
IM	241	Accounting I	(2-3)3
IM	321	Industrial Marketing I	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
ME	263	Metals Processing	(1-2)1
PH	103	Physics	(4-1)4

Total credit hours 19

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	212	Economic Statistics II	(3-0)3
IM	242	Accounting II	(2-3)3
IM	322	Industrial Marketing II	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
PH	104	Physics	(4-2)4

Total credit hours 16

JUNIOR YEAR

First Semester

IM	307	Principles of Finance and Banking	(3-0)3
ME	315	Applied Mechanics	(3-0)3
ME	343	Heat and Power	(2-2)3
ME	377	Elements of Materials Science	(2-0)2
SS	303	Psychology I	(3-0)3

One of the Following Options †

AS	301	(A) Air Force Officer Development I	(4-2)2
IM	331	(B) Industrial Advertising	(3-0)3
IM	341	(C) Accounting III	(3-0)3
MA	205	(D) Calculus and Analytic Geometry	(4-0)4

Total credit hours 16, 17, or 18

Second Semester

EC	302	Labor Economics	(3-0)3
IM	344	Cost Accounting	(2-2)3
IM	360	Business Law	(3-0)3
ME	372	Strength of Materials	(3-0)3
SS	226	Europe Since 1914	(3-0)3

One of the Following

AS	302	(A) Air Force Officer Development II	(2-2)1
and			
SS	306	(A) Sociology	(3-0)3
IM	334	(B) Export Sales Management	(3-0)3
IM	342	(C) Accounting IV	(3-0)3
MA	206	(D) Differential Equations	(3-0)3

Total credit hours 18 or 19

†The specialization sequence selected by the student should be followed through the senior year.

SENIOR YEAR

First Semester

EC	301	Economic Development of the United States	(3-0)3
EE	351	Industrial Electronics	(3-0)3
IM	411	Production Management I	(3-0)3
IM	461	Personnel Management	(3-0)3
SS	305	Sociology	(3-0)3

One of the Following

AS	401	(A) Global Relations I	(2-2)1
	and		
SS	403	(A) Foundations of National Power	(3-0)3
IM	421	(B) Procurement	(3-0)3
IM	441	(C) Accounting V	(3-0)3
PH	205	(D) Physics	(4-2)4

Total credit hours 18 or 19

Second Semester

EC	402	Government and Business	(3-0)3
EC	412	Managerial Economics	(3-0)3
IM	412	Production Management II	(3-0)3
ME	494	Industrial Instrumentation	(2-0)2
		Special Major Elective*	(3-0)3

One of the Following

AS	402	(A) Global Relations II	(1-2) ½
	and		
SS	460	(A) International Relations	(3-0)3
IM	444	(B) Sales Management	(3-0)3
IM	442	(C) Accounting VI	(3-0)3
PH	206	(D) Physics	(4-2)4

Total credit hours 17, 17½ or 18

*EC 414, IM 470, IM 480, IM 484, IM 502 or IM 504. Other subjects by approval of advisor only.

Mechanical Engineering

This course trains the student in the application of the facts and methods of mathematics and science to the design and use of machinery and processes. Principles of design and analysis are stressed in all subjects, and the systems point of view is emphasized.

The student is thoroughly instructed in basic mathematics, physics, and chemistry. There is a unified sequence in applied mechanics which focuses on a course in design given in the senior year. The properties of engineering materials and the principles of thermodynamics, fluid mechanics, and heat transfer are taught, together with a series of subjects in electrical engineering.

In the laboratory the student becomes familiar with design techniques associated with typical energy conversion devices, controls, and instrumentation.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	201	Economics I	(3-0)3
EE	201	Fundamentals of Electrical Engineering I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total credit hours			19

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-2)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	206	Physics	(4-2)4
Total credit hours			18

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	375	Materials Science	(3-2)3
Two General Electives			(6-0)6
Total credit hours			18

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
MA	356	Digital Computer Programming	(1-2)1
ME	314	Mechanical Engineering Laboratory I	(0-3)1
ME	318	Applied Mechanics IV	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
		General Elective	(3-0)3

Total credit hours 18

SENIOR YEAR

First Semester

EE	415	Electromechanical Engineering	(3-3)4
ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	443	Heat Transfer	(3-0)3
		General Elective	(3-0)3
		One Technical Elective	3

Total credit hours 17

Second Semester

EE	416	Electromechanical Engineering	(2-3)3
ME	416	Mechanical Engineering Laboratory III	(0-3)1
ME	476	Physical Metallurgy	(3-0)3
ME	492	Engineering Systems	(2-0)2
		General Elective	(3-0)3
		Two Technical Electives	6

Total credit hours 18

Nuclear Engineering

The Nuclear Engineering course is the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	201	Economics I	(3-0)3
EE	201	Fundamentals of Electrical Engineering I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total credit hours			19

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-2)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	206	Physics	(4-2)4
Total credit hours			17

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
NU	301	Nuclear Radiation and Radiological Safety	(3-0)3
PH	343	Atomic Physics	(3-1)3
		General Elective	(3-0)3
Total credit hours			18

Second Semester

MA	302	Advanced Calculus	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	380	Physical Metallurgy	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
PH	362	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3
Total credit hours			18

SENIOR YEAR

First Semester

ME	443	Heat Transfer	(3-0)3
NU	401	Nuclear Engineering I	(3-0)3
NU	403	Reactor Instrumentation I	(2-4)3
NU	405	Reactor Operations and Analysis I	(3-2)4
PH	461	Nuclear Physics	(3-0)3
		General Elective	(3-0)3
Total credit hours			<u>19</u>

Second Semester

CH	484	Nuclear Chemistry and Radiochemistry	(3.3)4
NU	402	Nuclear Engineering II	(3-0)3
NU	404	Reactor Instrumentation II	(2-4)3
NU	406	Reactor Operations and Analysis II	(3-2)4
PH	462	Nuclear Physics	(3-0)3
		General Elective	(3-0)3
Total credit hours			<u>20</u>

Nuclear Science

The course in Nuclear Science is the first to be offered by a publicly supported institution in New England. The curriculum emphasizes those fundamental subjects in physics and mathematics necessary for a basic education in all sciences and thus prepares the graduate for advanced studies as well as for responsible positions in industry.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
LL	261	Elementary Technical German	
	or		(3-0)3
LL	265	Elementary Technical Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
PH	211	Intermediate Mechanics	(3-0)3
PH	251	Intermediate Electricity	(3-3)4
Total credit hours			20
*Alternate:	SS 223,	The United States Since 1865	(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EE	204	Introductory Electronics	(3-2)4
LL	262	Elementary Technical German	
	or		(3-0)3
LL	266	Elementary Technical Russian	
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(4-2)4
PH	222	Intermediate Thermodynamics	(3-0)3
Total credit hours			17

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
NU	301	Nuclear Radiation and Radiological Safety	(3-0)3
PH	311	Physical Mechanics	(3-0)3
PH	343	Atomic Physics	(3-1)3
PH	353	Electromagnetic Theory	(3-0)3
		General Elective	(3-0)3
Total credit hours			18

Second Semester

MA	302	Advanced Calculus	(3-0)3
NU	352	Nuclear Instrumentation I	(2-4)3
PH	324	Statistical Mechanics	(3-0)3
PH	358	Electrical Measurements	(2-3)3
PH	362	Intermediate Nuclear Physics	(3-0)3
		General Elective	<u>(3-0)3</u>

Total credit hours 18

SENIOR YEAR

First Semester

CH	483	Nuclear Chemistry and Radiochemistry	(3-3)4
MA	433	Matrix Algebra	(3-0)3
PH	411	Quantum Theory	(3-0)3
PH	461	Nuclear Physics	(3-0)3
PH	471	Solid State Physics	(3-0)3
		General Elective	<u>(3-0)3</u>

Total credit hours 19

Second Semester

MA	484	Calculus of Probabilities	(3-0)3
NU	452	Nuclear Instrumentation II	(2-4)3
PH	412	Quantum Theory	(3-0)3
PH	462	Nuclear Physics	(3-0)3
PH	472	Solid State Physics	(3-0)3
		General Elective	<u>(3-0)3</u>

Total credit hours 18

Paper Technology

The object of the Paper Technology course is to prepare graduates for work in the papermaking, paper-converting, or allied industries. A thorough training in basic chemical engineering is offered, accompanied by instruction in the theory and practice of pulp and paper manufacture and paper converting. Paper Technology involves the application of cellulose and plastics chemistry together with engineering principles to the handling of the material in the web or sheet form, as it is treated, coated, or converted into the final product.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
CH	201	Organic Chemistry	(3-3)4
LL	213	Introduction to English Literature	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	315	Applied Mechanics	(3-0)3
PH	205	Physics	(4-2)4
Total credit hours			20

*Alternate:	SS 223, The United States Since 1865	(2-0)2
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Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
CHE	202	Introduction to Chemical Engineering	(3-0)3
ME	372	Strength of Materials	(3-0)3
PH	206	Physics	(4-2)4
Total credit hours			19

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
CHE	301	Industrial Stoichiometry	(3-0)3
ME	341	Thermodynamics	(3-0)3
PA	301	Pulp Technology	(3-0)3
PA	303	Pulp Laboratory	(2-6)4
		General Elective	(3-0)3
Total credit hours			20

Second Semester

CH 332	Physical Chemistry	(3-3)4
CHE 304	Chemical Engineering	(4-0)4
CHE 312	Chemical Engineering Thermodynamics	(3-0)3
PA 302	Paper Technology	(3-0)3
PA 304	Paper Laboratory	(1-6)3
	General Elective	(3-0)3
Total credit hours		20

SENIOR YEAR

First Semester

CHE 405	Chemical Engineering	(4-0)4
CHE 411	Chemical Engineering Laboratory	(0-6)2
PA 403	Converting Technology	(3-0)3
PA 405	Converting Laboratory	(1-6)3
PA 413	Paper Problems	(1-0)1
PL 201	Plastics Technology I	(2-0)2
	General Elective	(3-0)3
Total credit hours		18

Second Semester

CH 334	Colloid Chemistry	(3-0)3
CHE 410	Plant Design	(3-0)3
PA 414	Paper Problems	(1-6)3
PL 202	Plastics Technology I	(2-0)2
	General Elective	(3-0)3
	Technical Elective	3
Total credit hours		17

Physics

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EE	201	Fundamentals of Electrical Engineering I	(3-0)3
LL	261	Elementary Technical German	(3-0)3
	or		
LL	265	Elementary Technical Russian	(4-0)4
MA	205	Calculus and Analytic Geometry	(4-2)4
PH	205	Physics	(3-0)3
PH	211	Intermediate Mechanics	
Total credit hours			19

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EE	204	Introductory Electronics	(3-2)4
LL	262	Elementary Technical German	(3-0)3
	or		
LL	266	Elementary Technical Russian	(3-0)3
MA	206	Differential Equations	(1-2)1
ME	264	Metals Processing	(4-2)4
PH	206	Physics	(3-0)3
PH	222	Intermediate Thermodynamics	
Total credit hours			18

JUNIOR YEAR

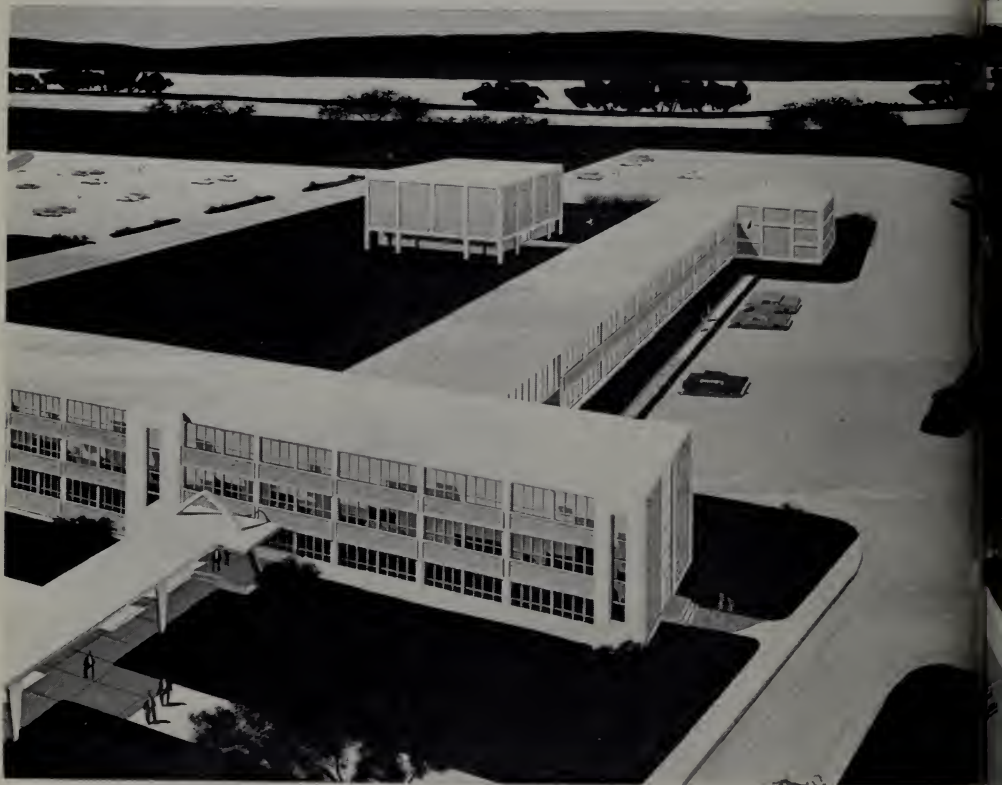
First Semester

MA	301	Advanced Calculus	(3-0)3
PH	311	Physical Mechanics	(3-0)3
PH	343	Atomic Physics	(3-0)3
PH	353	Electromagnetic Theory	(2-3)3
PH	357	Electrical Measurements	(3-0)3
		General Elective	
Total credit hours			18



Above: Architects' Proposal

Below: Proposed Nuclear Center Plan





New Residence Halls

Whester Browne & Associates, Architects



Second Semester

MA	302	Advanced Calculus	(3-0)3
ME	314	Mechanical Engineering Laboratory I	(0-3)1
PH	324	Statistical Mechanics	(3-0)3
PH	348	Physical Optics	(3-0)3
PH	362	Intermediate Nuclear Physics	(3-0)3
		Two General Electives	(6-0)6
			19
Total credit hours			19

SENIOR YEAR

First Semester

MA	433	Matrix Algebra	(3-0)3
PH	411	Quantum Theory	(3-0)3
PH	461	Nuclear Physics	(3-0)3
PH	471	Solid State Physics	(3-0)3
PH	493	Advanced Laboratory	(1-3)2
		Technical Elective	3
			17
Total credit hours			17

Second Semester

MA	484	Calculus of Probabilities	(3-0)3
PH	412	Quantum Theory	(3-0)3
PH	472	Solid State Physics	(3-0)3
PH	494	Advanced Laboratory	(1-3)2
		General Elective	(3-0)3
		Technical Elective	3
			17
Total credit hours			17

SENIOR YEAR

(Experimental Option)

First Semester

MA	459	Digital Computer Programming and Operation	(2-3)3
PH	493	Advanced Laboratory	(1-3)2
		Experimental Electives	4
		Two Senior Electives (Theory)	6
		Technical or General Elective	3
			18
Total credit hours			18

Second Semester

MA	460	Digital Computer Programming and Operation	(2-3)3
PH	494	Advanced Laboratory	(1-3)2
		Experimental Electives	4
		General Elective	(3-0)3
		Two Senior Electives (Theory)	6
			18
Total credit hours			18

Plastics Technology

The training of personnel specifically prepared to cope with the many technical and production problems found in the expanding field of plastics fabrication is the objective of the course in Plastics Technology. Emphasis is on the engineering principles involved in the fabrication of plastics materials into useful forms rather than the chemistry involved in the manufacture of the plastics material itself. However, the curriculum involves considerably more chemistry than most engineering courses, owing to the close relationship between the physical and chemical properties of such materials. Problems of design, manufacture, and testing in the plastics industry are closely studied.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
CH	201	Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(2-6)4
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
PL	201	Plastics Technology I	<u>(2-0)2</u>
Total credit hours			20

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
MA	384	Statistical Methods	(3-0)3
PH	206	Physics	(4-2)4
PL	202	Plastics Technology I	<u>(2-0)2</u>
Total credit hours			18

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
*EC	201	Economics I	(3-0)3
EE	355	Electronic Controls and Power Circuits	(3-2)4
ME	261	Machine Tool Laboratory	(1-2)1
ME	315	Applied Mechanics	(3-0)3
PL	301	Plastics Technology II	<u>(2-2)3</u>
Total credit hours			18

*ROTC students will substitute AS 301 (4-2)2.

Second Semester

CH	332	Physical Chemistry	(3-3)4
*EC	202	Economics II	(3-0)3
ME	372	Strength of Materials	(3-0)3
ME	374	Plastics Mold Design and Construction	(1-2)1
ME	376	Materials Science	(3-2)3
PL	302	Plastics Technology II	(2-2)3

Total credit hours 17

*ROTC students will substitute AS 302 (2-2)1 and SS 306, Sociology (3-0)3.

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4)4
PL	401	Plastics Technology III	(2-3)3
PL	403	Properties of Polymers	(4-0)4
PL	411	Plastics Seminar	(1-0)1
		Two Electives	(6-0)6

Total credit hours 18

Second Semester

CH	404	Chemistry of High Polymers	(3-4)4
ME	382	Fluid Mechanics	(3-0)3
ME	494	Industrial Instrumentation	(2-0)2
PL	402	Plastics Technology III	(2-3)3
PL	404	Properties of Polymers	(0-3)1
PL	412	Plastics Seminar	(1-0)1
		Elective	(3-0)3

Total credit hours 17

Suggested Electives

CH	406	Atomic and Molecular Structure	(3-0)3
CH	423-424	Advanced Organic Chemistry	(3-0) (3-0)6
IM	483 or 484	Statistical Quality Control	(3-0)3
LL	261-262	Elementary Technical German	(3-0) (3-0)6
MA	206	Differential Equations	(3-0)3
MA	487 or 488	Advanced Statistical Methods	(3-0)3

Textile Engineering

This course is based on a sound training in mathematics and science and their application to the solution of technical problems. The curriculum is similar to and related to that in Mechanical Engineering but includes sufficient subjects in textile science to qualify the student for positions in either production or research in the textile industry.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	201	Economics I	(3-0)3
EE	201	Fundamentals of Electrical Engineering I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total credit hours			19

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-2)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	206	Physics	(4-2)4
Total credit hours			18

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	375	Materials Science	(3-2)3
TE	361	Textile Systems I	(4-4)4
		General Elective	(3-0)3
Total credit hours			19

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
MA	356	Digital Computer Programming	(1-2)1
ME	314	Mechanical Engineering Laboratory I	(0-3)1
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
TE	362	Textile Systems II	(4-2)4
		General Elective	(3-0)3
Total credit hours			19

SENIOR YEAR

First Semester

EE	415	Electromechanical Engineering	(3-3)4
ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	443	Heat Transfer	(3-0)3
TE	471	Textile Evaluation I	(2-3)3
TE	483	Engineering Design of Textile Structures	(3-0)3
		General Elective	(3-0)3

Total credit hours 20

Second Semester

ME	416	Mechanical Engineering Laboratory III	(0-3)1
ME	422	Machine Design	(2-3)3
ME	492	Engineering Systems	(2-0)2
TE	482	Application of Scientific Methods to Textile Processes	(3-0)3
TE	484	Engineering Design of Textile Structures	(3-0)3
		Two General Electives	(6-0)6

Total credit hours 18

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS	Air Science	MA	Mathematics
CH	Chemistry	ME	Mechanical Engineering
CHE	Chemical Engineering	NU	Nuclear Science and Engineering
EC	Economics	PA	Paper
EE	Electrical Engineering	PH	Physics
IM	Industrial Management	PL	Plastics
LL	Languages and Literature	SS	Social Sciences
LS	Life Science	TCH	Textile Chemistry
		TE	Textiles

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are restricted to graduate students. An asterisk following the subject number, e.g., PH 411-412*, indicates a subject which, although it is primarily for undergraduates, may ordinarily be taken for full graduate credit.

Odd numbers designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Hyphenated numbers indicate subjects continuing throughout the year.

Prerequisites are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

Air Science

AS 101-102 Foundations of Aerospace Power (0-2) (2-2)2 **I and II**

A survey of the constituent elements of aerospace power, basic aeronautical science, and the organization and operation of the military arm of the Federal government.

AS 201-202 Fundamentals of Aerospace Weapon (2-2) (0-2)2 **Systems I and II**

An introduction to aerospace missile and aircraft and their propulsion systems; aerospace defense; modern targeting and electronics warfare; high explosive, nuclear, chemical, and biological warheads; and aerospace strategic and tactical organizations and operations with contemporary Air Force weapon systems. Includes problems, mechanics, and military implications of present and future space operations, and contemporary aerospace military thought.

AS 301-302 Air Force Officer Development I and II (4-2) (2-2)3

Staff organization and functions, and the skills required for effective staff work, to include oral and written communication, observing, and individual and group problem solving; basic psychological and sociological principles of leadership and their application to leadership practice and problems; and an introduction to military justice.

AS 401-402 Global Relations I and II (2-2) (1-2)1½

An intensive study of global relations of special concern to the Air Force officer, with emphasis on international relations and geography. Weather and navigation and briefing for commissioned service are also included.

Chemistry

CH 101-102 General Chemistry (4-3) (4-3)8

Chemical principles and calculations. The chemistry of both metallic and nonmetallic elements and of their compounds and a brief survey of organic chemistry.

CH 201-202 Organic Chemistry (3-3) (3-3)8 **[CH 102]**

The classification, nomenclature, structure, mechanism of reaction, and behavior in bulk of important kinds of organic species. The laboratory work illustrates the experimental techniques which can be used to react, purify, characterize, and identify organic substances.

CH 203 **Elementary Organic Chemistry** **(3-0)3**
[CH 102]

This subject enables students not majoring in chemistry to become conversant with the names, structural formulas, properties, and uses of some important industrially available organic substances and with the role which organic chemistry plays in industry and engineering.

CH 205 or 206 **Qualitative Analysis** **(2-6)4**
[CH 102]

Mass action principles and systematic analysis of inorganic compounds by semi-micro technique. Offered both semesters.

CH 211 or 212 **Quantitative Analysis** **(3-6)5**
[CH 102]

The fundamental principles of quantitative analysis. The principles and calculations of gravimetric analysis, including an introduction to mineral separations as well as the analysis of soluble salts; the principles and calculations of volumetric analysis, including neutralization methods, oxidation-reduction methods, and iodometric methods. Offered both semesters.

CH 321 **Organic Chemistry Laboratory II** **(0-6)2**
[CH 202]

A continuation of the laboratory portion of CH 202 involving additional laboratory work in synthetic organic chemistry.

CH 331-332 **Physical Chemistry** **{3-3}(3-3)8**
[CH 102, MA 205, PH 205]

The formulation and development of the mathematical and mechanical models of theoretical chemistry and their uses in the solution of the practical problems of chemistry and chemical engineering. Topics included are atomic and molecular structure, states of matter, thermodynamics, thermochemistry solutions, electrochemistry, colloids, chemical equilibrium, kinetics, and photochemistry.

CH 334 **Colloid Chemistry** **(3-0)3**
[CH 331 or equivalent]

Theoretical properties of the colloid system. Interfacial phenomena, particle kinetics, electrical properties, and viscosity characteristics are studied. The character of lyophobic and lyophilic sols, gels, and emulsions are developed from the above properties.

CH 342 **Organic Qualitative Analysis** **(1-6)3**
[CH 202; CH 205 or 206]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 402* History of Chemistry Seminar (1-0)1

A seminar for seniors and graduate students in chemistry. The history of chemistry and the philosophy of science. Assigned readings discussed under the guidance of selected faculty members.

CH 403-404* Chemistry of High Polymers
undergraduates (3-4) (3-4)8
graduates (3-0) (3-0)6
[CH 202 and 332]

Definition and classification of high polymers; chemistry of the more important polymers, including preparation, physical properties, and chemical properties; mechanism and procedures for polymerization, copolymerization, and condensation; physicochemical investigations, including molecular weight determination and distribution; the structure of high polymers, including relationship of structure to properties; inter- and intra-molecular forces; states of aggregation; transition points; elasticity; viscoelastic behavior; cross-linking; plasticization (internal and external); and solvent action.

CH 406* Atomic and Molecular Structure (3-0)3
[CH 332]

Modern concepts of atomic and molecular structure are developed, and the theory is related to observed chemical phenomena.

CH 408 and/or 409 Advanced Studies in Chemistry Credits to be arranged

[Permission of the Chairman of the Chemistry Division and the instructor]

Advanced work in analytical, organic, inorganic, physical, or textile chemistry, including literature survey, laboratory work, and reports.

CH 411 Advanced Quantitative Analysis (2-4)3
[CH 202; CH 211 or 212]

Advanced principles and techniques of analytical separations, with laboratory emphasis on some instrumental methods. Fractional precipitation methods, colorimetry, chromatography, compleximetry, potentiometric titrations, polarography, and organic precipitating agents. Group projects and report writing.

CH 423-424* Advanced Organic Chemistry (3-0) (3-0)6
[CH 202]

Extension of first-year organic chemistry to include additional classes of compounds and special topics. Emphasis is placed on synthetic methods, including the mechanism, scope, and limitations of the important name reactions in the field of synthetic organic chemistry.

CH 431-432* **Advanced Physical Chemistry** **(3-0) (3-0)6**
[CH 332]

An extension of introductory physical chemistry for majors in chemistry and related fields, including additional work in chemical thermodynamics, kinetics, and equilibrium as they apply to the various chemical phenomena, with emphasis on the use of chemical literature, methods of treating data, and problem solving.

CH 443-444* **Advanced Inorganic Chemistry** **(3-0) (3-0)6**
[CH 202 and 411]

Advanced chemistry of the common elements and their compounds, including coordination complexes, inorganic stereoisomerism, ion exchange, etc.

CH 473 or 474 **General Biochemistry** **(2-3)3**
[CH 201-202 or permission of instructor]

The chemistry and metabolism of carbohydrates, proteins, and fats, and their products.

CH 481 **Radiochemistry** **(3-3)4**
[CH 332]

Presents fundamentals of radiochemistry, including radioactivity, atomic nuclei, nuclear reactions, reactors, and radiation detection and measurement. Emphasis is placed on the use of radioactive materials in chemical applications. Designed primarily for majors in chemistry and in allied fields.

CH 483 or 484 Nuclear Chemistry and Radiochemistry **(3-3)4**
[CH 102]

Includes review of chemical principles as applied to radiochemistry. Provides coverage of such topics as radioactivity, nuclear reactors, radiation chemistry, use of tracers in chemical applications, and separation and study of fission products.

CH 501 **Absorption Spectrophotometry and Color Measurement** **(2-3)3**

Theory and application of absorption spectrophotometry to the qualitative and quantitative analyses of chemical substances in both transparent and opaque media in the ultraviolet, visible, and near infrared ranges, including theories of color, vision, and subjective color evaluation.

CH 503 **Interpretation of Data** **(3-0)3**

Mathematical methods of analyzing, plotting, and interpreting experimental data. Lectures and exercises.

CH 507-508 **Chemistry Seminar** **(1-0) (1-0)2**

CH 512 Physical Chemistry of Surface-active Agents (2-0)2

A series of lectures on the physicochemical principles involved in the use of surface-active agents. The surface and bulk properties of the agents are studied and related to the over-all technical properties and uses.

CH 513 Physicochemical Methods (3-0)3
[CH 424]

Theory, applications, and limitations of important physical methods of analysis used in modern research. Methods include X-ray diffraction, ultraviolet and infrared spectroscopy, and microscopy (phase, polarization, and electron). Special attention is given to methods for determining the size and shape of macromolecules.

CH 521-522 Physical Organic Chemistry (3-0) (3-0)6
[CH 424]

Modern concepts of molecular structure developed and related to the physical and chemical properties of organic compounds. Polarization effects and reaction mechanisms considered in detail.

CH 523 Physical Chemistry of Macromolecules (3-0)3
[CH 404 and 432]

An advanced treatment of the physical chemistry of macromolecules, including methods available for molecular structure determination. Consideration of the thermodynamic and statistical approaches to the theory of high polymer solutions, with particular emphasis on molecular weight dependencies and a study of the kinetics of polymerization and depolymerization.

CH 524 Organic Chemistry of Macromolecules (3-0)3
[CH 403 and 424]

An advanced study in polymer science concerned with modern theoretical concepts and including mechanisms of formation and degradation of macromolecules.

CH 525 Chemistry of the Carbohydrates (3-0)3
[CH 332 or equivalent]

Starting with the chemistry of the simple sugars, this subject leads to a detailed study of the physical chemistry and the organic chemistry of the important polysaccharides, such as cellulose and starch, and of their industrially important derivatives.

CH 527-528 Stereochemistry (2-0) (2-0)4

The fundamental concepts of optical and geometrical isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds.

Offered in alternate years; will not be offered in 1962-63.

CH 531-532 Chemical Thermodynamics (3-0) (3-0)6
[CH 539-540 or equivalent]

An advanced subject in chemical thermodynamics, with emphasis on the recent mathematical developments in the description of chemical systems, and with attention given to current experimental methods of obtaining thermodynamic data. The chemical and physical scientific literature is used extensively.

CH 533 Statistical Mechanics for Chemists (3-0)3
[CH 539-540 or equivalent]

A continuation of the introductory statistical mechanics presented in CH 539-540. Current theories on such topics as configuration of polymer molecules, rubber elasticity, and solution structure, as well as principles of classical statistical mechanics.

CH 534 Quantum Mechanics for Chemists (3-0)3
[CH 539-540 or equivalent]

A continuation of the introduction to quantum mechanics in CH 539-540. Current theories on such topics as quantum mechanical treatment of crystalline solids, imperfect gases and liquids, and electromagnetic susceptibilities.

CH 535-536 Advanced Topics in Physical Chemistry (3-0) (3-0)6

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 537 Chemical Kinetics (3-0)3

The theoretical and empirical treatment of chemical kinetic data of both organic and inorganic chemistry as well as the methods of obtaining these data. The determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanisms, complex reactions, and absolute rate theory.

CH 538 Rheology (2-0)2

The general principles of the deformation and flow of matter under stresses studied qualitatively and quantitatively. Hookean and non-Hookean elasticity and Newtonian and non-Newtonian flow related to the properties of materials, especially in the field of high polymers.

CH 539-540 Theoretical Chemistry (3-0) (3-0)6
[CH 331-332 or equivalent]

The formal aspects of quantum mechanics, thermodynamics, and statistical mechanics providing a conceptual and mathematical background for interpreting the behavior of chemical systems.

CH 541-542**Graduate Thesis****Credits to be
arranged**

An independent investigation of a problem by the student in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

CH 561-562**Advanced Organic Synthesis****(2-0) (2-0)4**

[CH 423-424 or equivalent]

The application of known organic reactions to the synthesis of chemical species in such fields as the terpenes, steroids, alkaloids, antibiotics, and selected heterocyclic derivatives.

Offered in alternate years; will be offered in 1962-63.

CH 564**Organic Qualitative Analysis****(1-6)3**

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565**Metal-Organic Compounds****(3-0)3**

The chemistry of the important classes of metal-organic compounds, including bis-arene derivatives, as well as the organo-silicon, organo-boron, and organo-phosphorus classes.

Offered in alternate years; will not be offered in 1962-63.

CH 566**Heterocyclic Chemistry****(3-0)3**

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years; will not be offered in 1962-63.

CH 568**Principles in the Technology of
Organic Construction Materials****(3-0)3**

Application of the principles of polymer chemistry to the chemical technology of organic construction materials (orcons) such as textiles, plastics, paper, and leather. For example, it is shown how the principle of cross-linking is utilized to modify the performance properties of cotton and rayon (crease recovery), of wool (permanent pleating), rubber (vulcanization), textile finishes and plastics (curing), leather (tanning), and paper (wet strength), and how the principle of swelling is utilized to make these materials accessible to modifying agents as in finishing, dyeing, and plasticization.

Chemical Engineering

CHE 202 Introduction to Chemical Engineering (3-0)3
[CH 102]

Reaction rate, equilibrium, and related topics followed by an investigation of a segment of the chemical industry. Library research on selected topics, together with oral and written reports.

CHE 301 Industrial Stoichiometry (3-0)3
[CH 211; CH 205 or CHE 202]

The analysis of industrial processes in the chemical industry by application of material and energy balances.

CHE 304 Chemical Engineering (4-0)4
[CHE 301, MA 205]

Unit operations of fluid mechanics, transportation of fluids, size reduction, mixing, mechanical separations, flow of heat, and evaporation.

CHE 312 Chemical Engineering Thermodynamics (3-0)3
[ME 341]

Generalized equations of state, heats of reaction, and chemical equilibria. Application of thermodynamics to fluid flow, compression, refrigeration, and heat engines.

CHE 405 Chemical Engineering (4-0)4
[CHE 304]

Unit operations of mass transfer, gas absorption, distillation, leaching and extraction, crystallization, air-water contact operations, and drying.

CHE 407 Industrial Chemistry (3-0)3
[CHE 301]

Important industrial chemical processes studied quantitatively. The processes are analyzed by means of material and energy balances together with equilibrium and kinetic considerations.

CHE 410 Plant Design (3-0)3
[CHE 405]

The complete process design of a chemical plant undertaken as a class project. The design of each part of the process is economically evaluated and optimized, and results are incorporated in a final report.

CHE 411-412 Chemical Engineering Laboratory (0-6) (0-6)4
[CHE 304 and 405]

Experimental studies of various unit operations performed as co-operative efforts by groups of students. Written reports required.

Economics

EC 201 Economics I (3-0)3

The foundations and nature of economic principles. National income, money and banking, and monetary and fiscal policy.

EC 202 Economics II (3-0)3
[EC 201]

Price and production theories, the distribution of income, comparative economic systems, and a brief survey of economic doctrines.

EC 211-212 Economic Statistics I and II (3-0) (3-0)6

Basic concepts of statistical methods with special emphasis on those approaches of most interest to students of management. Topics covered include measures of central tendency, dispersion, frequency distributions, probability distributions, tests of hypotheses, regression analysis, multiple and partial correlation, time series, seasonal variations, index numbers, and analysis of variance.

EC 301 Economic Development of the United States (3-0)3

The background of the present economic system and an intensive study of the influence of science and technology upon our economic development.

EC 302 Labor Economics (3-0)3
[EC 202]

The effect of the operation of American capitalism upon the position of labor. Analysis of the rise of union organization and the factors in its growth. Consideration of trends in the labor forces, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 401 International Trade Theory (3-0)3
[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.



Physical Chemistry Experiment



Electrical Engineering Laboratory

EC 402 **Government and Business** **(3-0)3**
[EC 202]

An examination of federal, local, and state controls on business activity, with emphasis on the economic interpretation of the various statutes and court decisions involving business.

EC 412 **Managerial Economics** **(3-0)3**
[CH 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis, and competitive action.

EC 414 **Engineering Economy** **(3-0)3**
[EC 202, IM 242; or permission of instructor]

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

Electrical Engineering

EE 201-202 **Fundamentals of Electrical Engineering** **(3-0) (3-0)6**
I and II

[MA 108 and PH 104; MA 205-206 taken concurrently]

An introduction to the study of the mathematical and physical aspects of electric circuits in which radiation in the form of electromagnetic waves does not play a major role. Kirchhoff's laws, Thevenin's theorem, reciprocity of simple circuits, vector diagrams, vector algebra, sinusoidal steady state behavior of simple circuits, transients in alternating-current circuits, coupled circuits and transformers, polyphase systems, and an introductory discussion of simple nonlinear circuits.

EE 204 **Introductory Electronics** **(3-2)4**
[EE 201, MA 205]

A background subject in electronics for non-electrical engineering students, presenting the properties and uses of vacuum tube and semiconductor devices, with special emphasis on their application to instrumentation and control.

EE 301-302 **Electronics I and II** **(4-6) (6-6)14**
[EE 201-202, MA 205-206]

Principles and methods of analysis of electronic devices, models, circuit function, and systems; the use of piecewise-linear circuit models; transistor and electronic tube models and circuits; wave shaping and amplification; rectification and detection; wave-form generation; oscillations in RLC circuits; and symmetry and balanced circuits.

EE 303-304**Electromagnetics****(3-0) (3-0)6**

[EE 201, MA 206]

Electricity and magnetism presented from the field theory point of view, using vector analysis and Maxwell's equations. The static electric field in polarizable and conducting media, static magnetic fields of steady electric currents and ferromagnetic materials, time-changing electric and magnetic fields, magnetic induction, electromagnetic waves and energy flow, and boundary value problems.

EE 324**Electrical Energy Conversion****(3-2)4**

[EE 201, MA 205]

An introductory subject for non-electrical engineering students, presenting the generation, control, utilization, and conversion of electrical energy, with special attention given to the construction, characteristics, and operation of direct-current and alternating-current machinery, selsyns, and rectifiers.

EE 351**Industrial Electronics****(3-0)3**

[MA 108, PH 104]

Not open to students majoring in Electrical Engineering, Mechanical Engineering, Physics, or Textile Engineering.

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum and gaseous tube characteristics and of circuits containing such tubes for the purpose of rectification, amplification, and oscillation; and industrial photoelectric relays, time delay relays, and Thymotrol motor controls.

EE 355**Electronic Controls and Power Circuits****(3-2)4**

Power requirements in single-phase and three-phase power circuits; operating characteristics of various types of direct-current and alternating-current motors and their manual and automatic controls; and industrial electronics including photoelectric relays, time delay relays, and motor control.

EE 401-402**Feedback Control Systems and
Their Components****(4-0) (3-3)8**

[EE 302, MA 312]

The various methods of analysis and design of control systems, including the time-domain, frequency-domain, and root-locus approaches, and a broad coverage of control system components. Laboratory experiments and demonstrations are included in the second semester.

EE 403-404**Microwave Electronics****(3-0) (3-0)6**

[EE 304, MA 312]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, generation and focusing of high-current electron beams with electric and magnetic fields, electron optics, velocity modulation, space

charge wave propagation and traveling wave interaction with electron beams with application to microwave amplifiers and oscillators, and antennas.

EE 405-406 Communication Electronics (3-0) (3-0)6
[EE 302, MA 312]

Theory and application of thermionic tubes and transistors in amplifiers, oscillators, modulators, and detectors operating class A and in the switching mode. Principles of television communication.

EE 407-408 Pulse and Digital Circuits (3-0) (3-0)6
[EE 302]

Response of linear networks, both active and passive, to the types of wave forms commonly encountered in pulse circuits; effect of nonlinearities of tubes on wave form transmission; detailed analysis of wave form generating circuits and other fundamental building blocks; and basic circuits in pulse and digital systems.

EE 409-410 Solid State Physical Electronics (3-0) (3-0)6
[MA 312]

A physical interpretation of the properties of materials in terms of their dielectric constant, magnetic permeability, and electrical conductivity; dielectric, ferroelectric, and piezoelectric materials; diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic materials; metals, semiconductors, and insulators; and applications to electrical engineering devices.

EE 411-412 Logical Design of Digital Computers (3-0) (3-0)6
[EE 302]

Foundations for the complete design of digital computer subsystems, such as arithmetic unit, computer memory, control, and input-output equipment with emphasis on basic circuitry as well as the logical tools: flip-flops, shift-register, logical gates, and magnetic core memories. Boolean algebra, systems synthesis, coding, and error detection.

EE 413-414 Control Systems Engineering (3-0) (3-0)6
[MA 312]

Introduction to the design of large-scale systems, with emphasis on probability, statistics, modern switching algebra, use of matrices, information theory, linear programming, and theory of games. Quality control, feedback, simulation, models, human engineering, and economics of systems design.

EE 415 Electromechanical Engineering (3-3)4
[EE 204, MA 206]

Servomechanisms and their application to control problems, with emphasis on system analysis by block diagram using transfer function techniques; use of electrical analogs for analysis and design of mechanical systems.

EE 416 Electromechanical Engineering (2-3)3
[EE 415]

Characteristics of electromechanical transducers and their associated circuitry as employed in the measurement of acceleration, velocity, displacement, stress, strain, thickness, mass, weight, frequency, time, and level of intensity.

EE 421-422 Electronic Project Laboratory (0-4) (0-4)4

An opportunity for the student to carry out independent work in an area of special interest.

EE 423-424 Coherence Theory and Antennas (3-0) (3-0)6
[EE 304, MA 312]

Propagation of classical electromagnetic waves in physical media and consideration of radiation from various antenna configurations.

EE 425 Electronics III (3-4)5
[EE 302, MA 312]

Principles and methods of electronic switching, stable states and regenerative switching, timing systems, generation of linear voltage slopes, and pulse-forming networks.

EE 426 Electronics IV (3-0)3
[EE 425, MA 312]

Application of matrix, topological, and signal-flow-graph methods of circuit and system analysis; a unified treatment of signals based on the correlation function, the Fourier integral, and the Fourier series; analysis and synthesis of pulse, periodic, almost periodic, and random signals; transmission of signals through linear systems; nonlinear and time-varying linear systems described from the system viewpoint, the signal viewpoint, and the circuit viewpoint; and negative feedback concept.

EE 427-428 Transistor Electronics (3-4) (3-4)10
[EE 302, MA 312]

Properties of semiconductor devices and a study of transistors as active network elements, based on two-port theory, with analysis and design of associated transistor devices. Emphasis is placed on the basic techniques for solving transistor problems.

EE 431-432 Special Topics in Electronics (3-0) (3-0)6

An analytical consideration of special topics of importance in the field of electronics.

EE 434 Principles of Analog Computation (1-3)2
[EE 302, MA 312]

Principles of electric analog computing techniques. Development and application of analog methods to problems in engineering analysis.

EE 505-506 Microwave Electronics (3-0) (3-0)6

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers, klystrons, magnetrons, and traveling wave tubes.

EE 507-508 Intermediate Solid State Electronics (3-0) (3-0)6

An intensive study of selected topics in solid state electronics.

EE 509-510 Transients in Electromechanical Systems (3-0) (3-0)6

Training in the formulation and solution of ordinary and partial differential equations which arise in the treatment of mechanical, acoustical, thermal, and electrical systems, with extensive use of modern operational mathematical techniques.

EE 511-512 Dynamic Control Analysis (3-0) (3-0)6

The principles of electronic devices used for control and measurement in applied science and engineering.

EE 513-514 Electromagnetic Theory (3-0) (3-0)6

Maxwell's equations, stress and energy, the electrostatic field, the magnetostatic field, plane waves in isotropic media, cylindrical waves, spherical waves, radiation, and boundary value problems.

EE 521 Distributed Amplification (3-4)5
[EE 302, MA 312]

Basic concepts of distributed systems employing iterative structures; tube and transistor active elements in mixed lumped and distributed systems; discussion of millimicrosecond pulse measurement techniques; and measurement projects formulated for the concurrent laboratory.

EE 522 Parametric Amplification (3-4)5
[EE 302, MA 312]

Treatment of linear and nonlinear systems with varying parameters; solutions to the Mathieu-Hill differential equation; amplification with non-storage- and storage-type network elements; the pumped system with applications; and use of semiconductor devices as active network elements. Measurement projects are formulated for laboratory work.

EE 529-530 Network Synthesis (3-0) (3-0)6

The formulation of the fundamentals of network theory; establishing realizability conditions and synthesis techniques for various classes of networks and network functions; and methods for realizing one or more networks whenever a function of the given class is prescribed.

EE 531-532 Seminar in Electronics (1-0) (1-0)2

Discussion by staff members and students of current journal publications and topics of current interest in electronic science, electronic engineering, and related areas of applied physics.

EE 533-534 Special Problems in Electronics Credits to be arranged

An opportunity for individual study, under the direction of a staff member, of topics in or related to electronic engineering.

EE 535-536 Graduate Research Credits to be arranged

Supervised research and thesis on some problem in electronic science, electronic engineering, or certain areas of applied physics.

Industrial Management

IM 241-242 Accounting I and II (2-3) (2-3)6

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

IM 307 Principles of Finance and Banking (3-0)3
[EC 202]

The financial aspects of the various business forms, the banking and monetary system of the United States, and the role of the Federal Reserve System and the Treasury in terms of monetary and fiscal policy.

IM 321-322 Industrial Marketing I and II (3-0) (3-0)6
[EC 202]

Marketing principles and problems affecting the sale of industrial goods. Industrial market research, product research and development, pricing, and promotion.

IM 331 Industrial Advertising (3-0)3
[IM 321]

The principles and problems of advertising applied to the industrial field.

IM 441-442 Accounting V and VI (3-0) (3-0)6

[IM 342]

Advanced accounting, comprising the bridge between accounting principles and the actualities of large-volume modern business. Considers the measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

IM 444 Sales Management (3-0)3

[IM 322]

Management of the selling function in its broad aspect. Sales organization, compensation, selection, training, and supervision. Market research, product packaging and development, and distribution policies.

IM 461 Personnel Management (3-0)3

A comprehensive study of the techniques of recruiting, selecting, training, and placing of members of the work force, including such matters as employee health and safety, welfare and education, and wage and salary administration.

IM 470 Auditing (3-0)3

[IM 342]

Duties and responsibilities of the auditor, kinds of audits, programs of audits. Study of application of the theory and practice of accounting to auditing. Internal control and its relationship to the audit program. Working papers of the auditor, statements, and reports.

IM 480 Accounting Systems (3-0)3

[IM 342]

Principles of systems designs. Internal control, division of labor, routing of business papers, procedural practices. Systems modifications. Relationship of theory and practice of accounting to systems.

IM 483 or 484 Statistical Quality Control (3-0)3

[MA 383 or 384]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 501 or 502 Industrial Relations Seminar (3-0)3

[Permission of instructor]

This subject gives a small select group the opportunity to discuss and analyze current problems in industrial relations. Case material provides the basis of class work.

Engineering economy as applied to replacement and incremental cost analysis, design of production and inventory control systems, the use of digital computers in management control problems, and an introduction to linear programming through the use of selected readings and case problems.

Languages and Literature

LL 111-112 English^I and II (3-0) (3-0)6

Training in the composition of extended exposition. Introduction to logic and to basic research techniques. Analysis and evaluation of collateral readings in the humanities. Introduction to literature.

LL 213 Introduction to English Literature (3-0)3

Interpretation and criticism of selections from the basic types of English literature—fiction, poetry, drama, biography, and the essay.

LL 214 Introduction to American Literature (3-0)3

Interpretation and criticism of selections from the basic types of American literature—fiction, poetry, drama, biography, and the essay.

LL 233 Comparative Literature (3-0)3

A consideration of at least six classics of western civilization as keys to the development of modern culture.

LL 234 Shakespeare (3-0)3

Shakespeare's chief tragedies, comedies, and chronicles. Lectures and discussions of Shakespeare and the nature of man.

LL 261-262 Elementary Technical German (3-0) (3-0)6

An introduction to the study of the German language to develop a reading knowledge of scientific German. Limited practice in speaking and writing.

LL 263-264 Elementary Technical French (3-0) (3-0)6

An introduction to the study of the French language to develop a reading knowledge of scientific French. Students with less than two years of high-school French must take both semesters to receive credit. Students with two or more years of high-school French are not eligible for LL 263 but may enroll for credit in LL 264.

Graduate students may enroll in either or both semesters, but no credit will be granted.

LL 265-266 Elementary Technical Russian (3-0) (3-0)6

An introduction to the study of the Russian language to develop a reading knowledge of scientific Russian. Limited practice in speaking and writing.

LL 361-362 Intermediate Technical German (3-0) (3-0)6
[LL 262]

Intended to increase vocabulary and reading knowledge of scientific German. Further practice in speaking and writing in scientific terminology. Either semester may be taken separately.

LL 365-366 Intermediate Russian (3-0) (3-0)6

Intended to increase reading knowledge. Further practice in speaking and writing.

LL 367-368 Literary and Conversational German (3-0) (3-0)6
[LL 262]

Contemporary German literature with concentration on a contrast and comparison of 20th-century German and American literary trends. The direct method is used, and only German is spoken in class. An essay of about 600 words on some facet of German literature is required.

LL 369-370 Intermediate Literary Russian (3-0) (3-0)6
[LL 266 or equivalent]

Russian short stories and essays of moderate difficulty with explanatory notes and vocabulary, including some simplified versions of works by Lermontov, Pushkin, and Gogol.

LL 467 Advanced Seminar in Literary German (3-0)3
[LL 367-368 and permission of instructor]

Directed study in the works of two classical and two modern German writers. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

LL 468 Advanced Seminar in Literary German (3-0)3
[LL 367-368 with mark of A or B]

Directed study in the works of leading German authors, primarily in the field of nonfiction. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

LL 471 The Modern American Novel (3-0)3

A consideration of outstanding American novelists from 1920 to the present. Selected works of Faulkner, Fitzgerald, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3

The development of the novel in English literature from Conrad and Hardy through Huxley and Golding. Selected novels are read and discussed.

LL 473 World Drama (3-0)3

A general introduction to and survey of the main currents in world drama from its early beginnings in Greece to the modern plays of the European continent. Selected significant plays from the representative periods in the historical development of world theater are read and discussed.

LL 474 Modern Drama (3-0)3

An analysis of major forces in the theater from the time of Ibsen to the present. Selected representative plays of American and European dramatists.

LL 482 The American Short Story (3-0)3

A critical survey of the growth and development of the American short story. The works of Poe, Crane, Anderson, Hemingway, and Faulkner are among the writings considered.

Life Science

LS 101-102 Biology (3-3) (3-3)8

The principles of biology, including the origin of life, growth, reproduction, heredity, cellular physiology, and embryology.

LS 311 or 312 General Bacteriology (2-4)4

[CH 201-202 or permission of instructor]

The fundamentals of bacteriology, covering the morphology, physiology, and pure culture characteristics of bacteria.

LS 313 Microbiology (1-3)2
[CH 202]

The fundamentals of mycological and bacteriological theory as a background for the study of the microbiological deterioration of textiles, paper, and leather. Methods of detecting mildewing, methods of testing textiles for mildew resistance, and bacteriological water analysis.

LS 314 Leather Microbiology (2-4)4

[CH 202 or permission of instructor]

An introduction to microbiology, with special emphasis upon the microorganisms which may be encountered on skins or in the tannery.

A study of the structures of animal skin and of the changes which they undergo in the leather-making process. Because the basically extracellular nature of skin demands it, considerable time is devoted to the nature and function of the fundamental protein constituents.

Mathematics

MA 107 Calculus and Analytic Geometry (4-0)4

Functions and graphs, equations of straight lines, the differentiation and integration of algebraic functions together with applications involving related rates, differentials, maxima and minima, Mean Value Theorem, areas, volumes, lengths of curves, areas of surfaces of revolution, center of mass, the theorems of Pappus, pressure, and work.

MA 108 Calculus and Analytic Geometry (5-0)5 [MA 107]

The differentiation of exponential, logarithmic, and trigonometric functions; integration by parts, integration by partial fractions, integration by trigonometric substitution, other integral forms; determinants, both second and higher order; properties of roots of higher-degree equations; the conics, translation and rotation of curves, hyperbolic and inverse hyperbolic functions, polar coordinates, parametric equations, differentiation of vectors, and tangential and normal components of velocity and acceleration.

MA 205 Calculus and Analytic Geometry (4-0)4 [MA 108]

The scalar and vector products of two or more vectors, solid analytic geometry, space curves, curvature, arc length, partial differentiation, directional derivatives, gradient, chain rule, total differential, the method of least squares, maxima and minima of independent variables, line integrals, multiple integration, three-coordinate systems; series, including Maclaurin, Taylor, and Fourier series, indeterminate forms, tests for convergence of series; complex functions including the Argand diagram, DeMoivre's theorem, the Cauchy-Riemann equations, and logarithmic functions.

MA 206 Differential Equations (3-0)3 [MA 205]

The solution of ordinary differential equations and of partial differential equations of the first order and first degree and of forms in certain other orders and other degrees that lend themselves readily to solution. Practical applications to chemistry and engineering.

MA 301-302 Advanced Calculus (3-0) (3-0)6
[MA 206]

A further study of differential equations. The Laplace transformation, numerical methods for solving differential equations, series solutions of differential equations, boundary value problems and orthogonal functions, vector analysis, partial differential equations arising in mathematical physics, and problems suitable for the use of a complex variable. Extensive applications.

MA 306 Theory of Equations (3-0)3
[MA 108]

Mathematical induction, complex numbers, integral and rational roots, solution by radicals, impossibility of certain geometrical constructions, number of real roots, isolation of a root, determinants, and approximate methods of solution.

MA 311-312 Engineering Mathematics (4-0) (4-0)8
[MA 206]

Ordinary differential equations, Laplace transformation, numerical methods of solving differential equations, series solutions of differential equations, boundary value problems and orthogonal functions, vector analysis, partial differential equations, partial differential equations of mathematical physics, and complex variable theory.

MA 355 or 356 Digital Computer Programming (1-2)1
[MA 206]

The programming of a high-speed digital computer. Selected practice problems related to the specialties of the class. Programs written by the students are tested on the Institute's digital computer.

MA 383 or 384 Statistical Methods (3-0)3
[MA 205]

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

MA 406 Mathematical Statistics (3-0)3
[MA 205]

Measurements of dispersion, theoretical frequency distributions, tests of goodness of fit and independence, partial and multiple correlations; permutations, combinations, and probability; game theory.

MA 433* **Matrix Algebra** (3-0)3
[MA 205, PH 311]

Algebra of vectors, matrices, and determinants. Linear transformations. Linear vector spaces. Characteristic roots and reduction to diagonal form. Quadratic forms. Applications to physics.

MA 459-460* **Digital Computer Programming and Operation** (2-3) (2-3)6

An introduction to the use of digital computers for the solution of scientific and engineering problems. Programming techniques. The preparation and running of sample problems on the Institute's digital computer.

MA 484* **Calculus of Probabilities** (3-0)3
[MA 302]

Theory of arrangements. Introduction to probabilities. Stirling's theorem. Bernoulli's theorem. Random walk. Continuous distributions. Normal probability distribution. Poisson distribution. Elements of statistics.

MA 487 or 488 **Advanced Statistical Methods** (3-0)3
[MA 383 or 384]

A continuation of MA 383 or 384 with particular study of the more advanced statistical techniques. The design of industrial experiments and the analysis and interpretation of the resulting data.

MA 515 or 516 **Methods of Applied Mathematics** (3-0)3
The calculus of variations. Integral equations. Applications.

MA 525 or 526 **Modern Algebra** (3-0)3

Topics in modern algebra, including elementary properties of rational, real, and complex numbers; n -dimensional vector algebra; linear transformations; matrix theory; and the theory of groups, rings, integral domains, and fields.

MA 533 or 534 **Matrix Theory** (3-0)3

Linear vector spaces. The algebra of vectors and matrices. Linear transformations, special matrices, and quadratic forms. Characteristic roots and reduction to diagonal form. Applications to physics and quantum mechanics.

MA 537-538 **Group Theory** (3-0) (3-0)6

Elements of set theory. Mappings, isomorphisms, and cardinality. Semigroups and groups. The theory of finite groups. General representation theory. Applications of group theory to quantum mechanics.

MA 541 or 542 Fourier Series and Boundary Value Problems (3-0)3
[MA 206]

The Fourier series as a tool of analysis. Dirichlet's theorem. Orthogonal functions; convergence tests; the Fourier integral. Cylindrical and spherical harmonics. Boundary value problems.

MA 543 or 544 Partial Differential Equations I (3-0)3
[MA 302]

Ordinary differential equations in more than one variable, partial differential equations of first order, and partial differential equations of second order and higher. Emphasis is placed on those equations which arise in physical applications.

MA 545 or 546 Partial Differential Equations II (3-0)3
[MA 543 or 544; MA 573 or 574]

The Cauchy problem. Classification of equations. Special emphasis on hyperbolic, elliptic, and parabolic differential equations. Existence and uniqueness theorems; dependence of solutions on boundary conditions.

MA 553 or 554 Tensor Analysis (3-0)3
[MA 433 or 533]

The tensor concept. Covariant and contravariant tensors. The metric tensor, associated tensors, and covariant differentiation. Euclidean and Riemannian manifolds. Applications to geometry and analytical mechanics.

MA 557-558 Computers (3-2) (3-2)8
[MA 302, PH 254]

The principles of analog and digital computers as a basis for assessing and planning their use in scientific work. Logic design, instrumentation, programming, and numerical analysis. A survey of well-known commercial analog and digital computers. Experience with the computers at the Institute and also a visit to a local computing center having different equipment, during which a course-programmed problem may be run.

MA 563 or 564 Projective Geometry (3-0)3
[MA 205]

An introduction to various non-Euclidean geometrics. Point sets on a line, line pencils, homogeneous coordinates, theory of conics and quadrics. Multidimensional geometry, Plucker coordinates, correlations and colineations in space.

MA 573 or 574 Functions of a Complex Variable (3-0)3

Complex numbers, point sets, and elementary functions. An introduction to regular analytic functions. Classification of singularities. Conformal mapping and applications.

MA 575 or 576 Transform Analysis of Linear Systems (3-0)3
[MA 302]

Mathematical theory of Laplace and Fourier transforms and their application to the analysis of linear systems. The expression of initial conditions, the relation of functions of time to corresponding functions of a complex variable, the relation of linear differential equations with constant coefficients to corresponding algebraic equations, and the interpretation of linear system behavior by a study of its poles zeros in the complex plane. Characterization of physical systems by transfer functions and the response of some physical systems to step, impulse, and sinusoidal inputs.

MA 585-586 Random Processes and Noise Theory (3-0) (3-0)6
[MA 302]

Principles of random noise theory and optimum filtering. Development of the concepts of correlation function and power spectra for the detection of signals in noise. Illustration of the theory in some applications of circuits and computers with emphasis on the formulation of the noise problem, its mathematical solution, and the interpretation of the results for proper design of systems.

MA 591 or 592 Graduate Thesis Credits to be arranged

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

Mechanical Engineering

ME 101 Engineering Graphics (1-2)1

Communication by graphic representation—orthographic and pictorial. Charts and graphs. Freehand and instrumental multiview drawing, dimensioning, engineering geometry, pictorial sketching, and projection.

ME 102 Engineering Graphics (1-2)1
[ME 101]

The use of graphics in the solution of problems. Visualization by descriptive geometry, and its exercise in vector geometry and intersections. Graphical calculus, nomography, and empirical equations.



Cumnock Hall—Auditorium—Administration Building

ME 211 or 212 Applied Mechanics I (3-0)3
[MA 108, PH 103]

A development of fundamental ideas such as vector, force, and moment. A detailed treatment of the free body diagram concept and its application to resultants of force systems, laws of static equilibrium, friction forces, first and second moments, and various structures and machine parts.

ME 214 Applied Mechanics II (3-0)3
[ME 211 or 212]

A continuation of ME 211 or 212. The basic laws of kinematics of particles and rigid bodies which involve linear, angular, relative, and absolute motion; Newton's laws and their applications to the kinetics of rigid bodies in translation, rotation, and plane motion; and the principles of work, energy, impulse, and momentum.

ME 261 or 262 Machine Tool Laboratory (1-2)1

Metals processing. Basic machine tools such as the lathe, shaper, drill-press, and milling machine, as well as the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, die-casting, welding, and forging.

ME 263 or 264 Metals Processing (1-2)1

Modern methods of manufacture including casting, forging, metal cutting and turning, spinning, and welding; testing for hardness and tensile strength; shrink fits; and soldered and welded joints. Survey of current technical literature and special topic assignments.

ME 311 Applied Mechanics III (3-0)3
[ME 211 or 212]

A basic subject in strength of materials. Fundamentals of stress and strain and their applications. Tension, compression, shear, and combined stresses; the Mohr circles for stress and strain; shearing force and bending moment diagrams; stresses and deflections of beams in bending; statically indeterminate problems; torsion of circular and rectangular sections.

ME 314 Mechanical Engineering Laboratory I (0-3)1

Experimental work in the various fields of mechanical engineering to gain an appreciation of measurable quantities, analytical approaches, and measuring equipment and techniques. Design, analysis, and synthesis of engineering systems are stressed throughout. The student is encouraged to devise his own experiments and to obtain and analyze the engineering data required for design.

ME 315

Applied Mechanics

(3-0)3

[MA 108, PH 103]

Not open to students majoring in Electrical Engineering, Mechanical Engineering, or Textile Engineering.

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 317 or 318

Applied Mechanics IV

(3-0)3

[ME 214]

The fundamental ideas of statics and dynamics applied to general systems with oscillatory motion. The kinematics of periodic motion; free, undamped, damped, and forced vibrations of systems with a single degree of freedom; energy methods, systems with multiple degrees of freedom, and influence coefficients; and tabular methods for calculation of natural frequencies.

ME 341

Thermodynamics

(3-0)3

[MA 205, PH 205]

Heat and work, the first law, the concept of reversibility, and the second law. The pure substance, the perfect gas, and Maxwell's relations. The Carnot and other energy conversion cycles. The energy and entropy associated with electric and magnetic fields and with electromagnetic radiation. The relationships among entropy, probability, and information.

ME 342

Thermodynamics

(3-0)3

[ME 341]

Reversible and irreversible processes, flow processes, properties of fluids with application of thermodynamic charts and tables, shock-waves and the Rankine-Hugoniot equations, chemical reactions, mixtures and chemical equilibria, combustion, the third law, and electrochemical cells.

ME 343 or 344

Heat and Power

(2-2)3

[MA 108, PH 104]

Not open to students in Electrical Engineering, Mechanical Engineering, or Textile Engineering.

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 371 or 372

Strength of Materials

(3-0)3

[ME 211 or 212; 315]

Stress fundamentals, strain bending moment and deflection, beam design, torsion, columns, combined stresses, reversals of stress, and impact.

ME 374 Plastics Mold Design and Construction (1-2)1
[ME 261 or 262]

Principles of mold design and construction and of machining and finishing operations of plastics, and actual laboratory work in the design and construction of simple molds.

ME 375 or 376 Materials Science (3-2)3
[PH 206]

The dependence of the properties of materials in general on atomic and crystalline structure. X-ray and electron diffraction; equilibrium and rate processes; interatomic attractive forces; diffusion; theory of dislocations; mechanical, electrical, electronic, magnetic, and thermal properties. Standard physical tests and assigned projects are performed in laboratory

ME 377 or 378 Elements of Materials Science (2-0)2
(Not open to students in Electrical, Mechanical, or Textile Engineering)

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, cold work, and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 381 or 382 Fluid Mechanics (3-0)3
[MA 205, PH 205]

Properties of fluids; statics of fluids; flotation; relative equilibrium; dynamics of fluids, Bernoulli's theorem, measurement of velocity and pressure; cavitation and flow of viscous fluids; Reynolds' number; flow in pipes; flow with free surface; critical depth; weirs; orifices and nozzles; impulse and momentum in fluids; resistance of immersed and floating bodies; Froude's number, boundary layer; dynamics of compressible fluids; Mach's number; dynamical similitude and Pi theorem.

ME 415 Mechanical Engineering Laboratory II (0-3)1
[ME 314]

Continuation of ME 314.

ME 416 Mechanical Engineering Laboratory III (0-3)1
(ME 415)

An individual project selected by the student in consultation with the staff. The project must include phases of design, construction, and analysis. Both a formal written report and an oral presentation are required.

ME 421-422 Machine Design (2-3) (2-3)6
[ME 214 and 311]

The application of the principles of mechanics to the design of typical machine elements, such as shafts, springs, screws, belts, clutches, brakes,

bearings, gears, and cams. The principles of lubrication, with applications to design. Theories of failure and methods of establishing working stress levels are considered. The laboratory work consists of comprehensive projects that illustrate the close relationship between analysis and synthesis as they are applied to various machine design problems.

ME 431 or 432 Power Plant Systems (2-3)3
[ME 342]

Elements of the design of power plants and heating systems, internal combustion engines, and related subjects.

ME 441 or 442 Air Conditioning (2-3)2
[ME 342]

The principles of heating, ventilating, and refrigeration. The laboratory consists of design problems in the air conditioning of industrial buildings.

ME 433 or 444 Heat Transfer (3-0)3
[MA 206; ME 341 and 382]

Modes of heat transfer: conduction, radiation, forced and free convection. Dimensional analysis; heat transfer to boiling liquids and condensing vapors; over-all transfer of heat; finned surfaces and heat exchangers; and transient conduction.

ME 472 Experimental Stress Analysis (2-2)3
[MA 205, ME 311]

An introduction to some of the experimental techniques used in stress analysis. Photoelasticity, electrical strain gauges, brittle coating, and mechanical gauges considered in relation to the analysis of both static and dynamic stresses, with special attention to the application of these techniques in the study of industrial structures and machinery.

ME 475 or 476 Physical Metallurgy (3-0)3
[MA 206; ME 375 or 376]

A study of metals. Phase diagrams and transformations, the system carbon-iron, electrical and magnetic properties related to structure, thermal and optical properties, elasticity and plasticity (including creep), diffusion, recovery, recrystallization, grain growth, hardening, and heat treatment. Interpretation of microphotographs of polished and etched specimens is stressed, as is the application of the theory to industrial problems involving the failure of metals in service.

ME 491 or 492 Engineering Systems (2-0)2

Application of fundamental engineering principles in the solution of design problems which involve more than one engineering discipline, with emphasis on costs, useful life, reliability, safety, esthetics, miniaturization, maintainability, and interchangeability.

Not open to students majoring in Electrical Engineering, Mechanical Engineering, or Textile Engineering.

Modern methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level, and fluid flow; response characteristics of mechanical, electric, and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; closed-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

Nuclear Science and Engineering

NU 301 or 302 Nuclear Radiation and Radiological Safety (3-0)3

The basic physics of alpha, beta, and gamma radiation, with emphasis on more practical considerations. The absorption and scattering of gamma radiation with applications to the design of shielding systems for protection of personnel, and effects of intense radiation on biological systems, structural materials, and chemical reactions.

NU 351 or 352 Nuclear Instrumentation I (2-4)3

Electronic pulse circuitry, including amplifiers, discriminators, counting, coincidence, and pulse height circuits; and the measurement of resolving and response times. Specific experiments in nuclear instrumentation.

NU 401-402 Nuclear Engineering I and II (3-0) (3-0)6

[MA 301-302 and PH 362]

Nuclear theory, with emphasis on the production and reactions of neutrons. The theory of nuclear fission; the diffusion and slowing down of neutrons; homogeneous and heterogeneous reactors; the analysis and control of nuclear reactors; neutron transport theory and multigroup theory; the design of nuclear reactors, with emphasis on the shielding of the core; and specific types of reactors such as swimming pool, water boiler, research, and power.

NU 403-404 Reactor Instrumentation I and II (2-4) (2-4)6

Elements of servomechanisms; automatic control systems; electrical and electronic theory utilized in the measurement of reactor parameters such as reactivity, danger coefficients, and temperature coefficients; detection of neutron flux with fission, BF_3 , and ionization chambers; analysis and design of power-measuring and period-measuring instruments; and calibration of control rods and general reactor control devices.

NU 405-406 Reactor Operations and Analysis (3-2) (3-2)8
I and II

[NU 301 or 302; PH 362]

The mathematical theory and analysis of reactor dynamics, including the effects of transients on steady state operation; analysis of a reactor from a systems viewpoint; laboratory training in the actual operation of a reactor; and reactor measurements and experiments.

NU 451 or 452 Nuclear Instrumentation II (2-4)3

[PH 462 taken concurrently]

The general nature of detection systems for electrons, protons, neutrons, photons, and alpha particles; the nuclear and electronic characteristics of Geiger, proportional, scintillation, and spark counters; and applications to specific experiments in nuclear physics.

Paper

PA 301 Pulp Technology (3-0)3

[CH 211]

Lectures and problems concerning the technology of pulp manufacture by the groundwood, sulfite, alkaline, and semichemical processes. Bleaching methods are studied.

PA 302 Paper Technology (3-0)3

[CH 211]

Lectures and problems concerning the technology of paper manufacture. Stock preparation, filling and loading, sizing, coloring, special additives, paper machine operation, and finishing.

PA 303 Pulp Laboratory (2-6)4

[CH 211]

This as well as subsequent laboratory work is designed with a research-type approach to develop the student's ability to plan and analyze the experimental work and to reach logical conclusions from the results. Studies of the principal wood, rag, and wastepaper pulps with work in wood and pulp microscopy, bleaching, and evaluation of pulps for their papermaking value by physical and chemical testing methods. Detailed written and oral reports are required.

PA 304 Paper Laboratory (1-6)3

[CH 211]

The fundamental processing techniques used in paper manufacture, including investigations of stock preparation, filling and loading, coloring, use of additives, and sheet formation. Detailed written and oral reports are required.

(3-0)3

[PA 302 and 304]

Lectures and problems concerning the technology of paper and paper-board conversion by mechanical, coating, impregnating, laminating, and printing processes.

(1-6)3

[PA 403, usually taken concurrently]

Study of and practice in the use of the common techniques employed in the paper and paperboard industry with emphasis on the colloidal and rheological properties of materials used. Detailed written and oral reports are required.

(1-0) (1-6)4

A research problem connected with some phase of the pulp, paper-board, or converting industry is selected by the student in collaboration with the staff and an advisory committee from the industry. In the first semester a literature survey is performed, and a preliminary report outlining the problem and the proposed investigation is submitted. In the second semester the investigation is carried out, and a detailed formal report is written.

(0-12) (0-12)8

Every graduate student is required to prove his ability to carry on independent research by presenting a thesis on an approved subject.

(2-6) (2-6)8

Nonfibrous raw materials used in the specialty papermaking and paper-converting fields, with emphasis on recent developments and new uses. These materials are studied with regard to their chemical and physical properties, the technology of application, and processed sheet properties.

Physics

(4-1)4

[MA 107 taken concurrently]

The principles of mechanics, including composition and resolution of vectors, statics, moments, rectilinear motion, Newton's second law, motion of a projectile, work and energy, impulse and momentum, circular motion, rotational kinematics and dynamics, elasticity, harmonic motion, hydrostatics, surface tension, hydrodynamics, and viscosity.

PH 104**Physics****(4-2)4**

[MA 108 taken concurrently, PH 103]

The basic principles of electricity and magnetism, including the following topics: Coulomb's law, potential, d.c. circuits; the magnetic field, galvanometers, ammeters, voltmeters, wattmeters, the d.c. motor; magnetic field of a current and of a moving charge; induced electromotive force; capacitance and inductance; magnetic properties of matter; transients in circuits containing inductance, capacitance, and resistance; thermoelectricity; ferromagnetism and ferroelectricity; alternating currents, electromagnetic waves, and electronic phenomena.

PH 205**Physics****(4-2)4**

[MA 205 taken concurrently, PH 104]

Heat, sound, and optics, including the following: thermometry, quantity of heat, change of state, work and heat; heat transfer, thermal properties of matter, the first and second laws of thermodynamics; wave motion, vibrating systems, acoustical phenomena; the nature and propagation of light; reflection and refraction at a single surface; lenses and lens aberrations; optical instruments; illumination; color; chromaticity diagrams; interference and diffraction; resolution; polarized light; and properties of crystals.

PH 206**Physics****(4-2)4**

[PH 205]

Modern physics, including the atomic nature of matter and electricity, variation of mass with velocity, isotopes, the nature of radiant energy, black bodies and the origin of the quantum theory, photoelectricity, spectra, Bohr's theory of the atom, X-ray spectra, waves associated with material particles, the spinning electron, Pauli's principle, magnetic moment of an atom, the periodic system and quantum numbers, molecular structure, radioactivity, elementary particles, scattering and absorption of particles and photons, transmutation, fission, reactors, fusion, cosmic rays, mesons, hyperons, and relativity.

PH 211 or 212**Intermediate Mechanics****(3-0)3**

[MA 205 taken concurrently, PH 104]

Motion under an inverse square force, attractive or repulsive. Damped and forced vibrations. Elements of related mathematical topics, including vector analysis. Dynamics of a rigid body. Gyroscopic motion.

PH 222**Intermediate Thermodynamics****(3-0)3**

[MA 206 and PH 206 taken concurrently, CH 102]

Kinetic theory of gases. First and second laws of thermodynamics. Standard cycles. Equilibrium between phases. Chemical equilibrium. Thermoelectric phenomena. Nonquantum theory of black-body radiation. Third law of thermodynamics.

PH 244 **Optical Instruments** (1-2)2

[PH 206 taken concurrently]

The basic laws of optics and their application to various optical instruments used in industry, such as the microscope, telescope, refractometer, and colorimeter. Considerable emphasis in the laboratory work is placed on the general use of the microscope.

PH 251 **Intermediate Electricity** (3-3)4

[MA 205 and PH 205 taken concurrently]

Electric field, potential, Gauss's law, dipoles, Poisson's and Laplace's equations, image problems, dielectric theory, energy, capacitance, force, electric current, d.c. circuits, steady magnetic fields, electromagnetic induction, magnetic properties of matter, L-C-R circuits, analysis of a.c. circuits, and Maxwell's equations.

PH 311 or 312 **Physical Mechanics** (3-0)3

[PH 211]

Introduction to the calculus of variations, generalized coordinates, Hamilton's principle, theory of vibrating systems, normal coordinates, and elementary boundary value problems.

PH 323 or 324 **Statistical Mechanics** (3-0)3

[PH 222 and PH 311]

Introduction to the calculus of probabilities. Maxwell-Boltzmann statistics, Bose-Einstein statistics, Planck's theory of black-body radiation, and Fermi-Dirac statistics.

PH 343 or 344 **Atomic Physics** (3-1)3

[MA 206, PH 206]

The atomic models of Bohr and Sommerfeld. Quantum mechanics. One-electron, two-electron, multielectron systems. Doublet, triplet, and multiplet series. Zeeman effect. Paschen-Back effect. Stark effect. Correlation of theory with observation.

PH 347 or 348 **Physical Optics** (3-0)3

[PH 353 or 354]

The theoretical and experimental aspects of the phenomena of interference, diffraction, and polarization of electromagnetic waves, especially light and microwaves.

PH 353 or 354 **Electromagnetic Theory** (3-0)3

[MA 301 or 302 taken concurrently, PH 251]

Theory of electromagnetic fields. Polarization fields, solutions of Laplace's equation, magnetic potentials, Maxwell's equations and their application to guides and cavities. Fresnel's equations. The Hertzian oscillator.

PH 355 or 356 Physical Electronics (3-0)3
[MA 306, PH 206]

Motion of charged particles in electric and magnetic fields; kinetic theory of gases; basic processes in gases; behavior of electrons in solids; statistical theory of metals.

PH 357 or 358 Electrical Measurements (2-3)3
[MA 206, PH 206]

Precision of measurements, zero frequency and low frequency measurements by both deflection and null methods, amplifiers and tube electrometers, oscillographs, measurements at high frequencies, magnetic measurements, electrical measurements in mechanics, heat, acoustics, optics, and nuclear science.

PH 361 or 362 Intermediate Nuclear Physics (3-0)3
[MA 206, PH 206]

Rutherford scattering, nuclear radius, the elements of wave mechanics, cross sections, and nuclear reactions.

PH 411-412* Quantum Theory (3-0) (3-0)6
[MA 433 and MA 484 taken concurrently, PH 311 and 312]

Elements of classical mechanics. The Bohr-Sommerfeld theory; wave-particle dualities and the uncertainty principle. Schrodinger's equation and the wave mechanics of a particle. The general theory of quantum mechanics, matrix methods, and perturbation theory.

PH 431 or 432* Theory of Vibrations and Sound (3-0)3
[MA 301, PH 312]

Free, damped, and forced oscillations; forcing by pulses; coupled oscillations; the flexible string; end conditions; perturbations; the vibration of bars, membranes, and plates; sound waves; acoustic impedance; the radiation and scattering of sound; normal modes; and reverberation. Applications are stressed.

PH 461-462* Nuclear Physics (3-0) (3-0)6
[PH 361 or 362, MA 302]

Nuclear moments, parity and statistics, extranuclear effects of nucleus, effects of nuclear moments and parity on nucleus transitions, the deuteron, p-p and n-p scattering theory, alpha decay theory, beta decay systematics, ionization of matter by charged particles.

PH 471-472* Solid State Physics (3-0) (3-0)6
[PH 411-412 taken concurrently]

Crystal structure and X-ray and neutron diffraction. Free electron model. Band theory of solids. Quantum mechanical considerations. Lattice energy, lattice vibrations, infrared absorption. Lattice defects.

Thermal properties of solids. Dielectric and magnetic properties. Mechanical properties. Semiconductor crystals.

PH 493-494 Advanced Laboratory (1-3) (1-3)4
[Permission of instructor]

A laboratory course which accompanies the senior courses in the department and which may serve as a vehicle for undergraduate experimental research in selected fields of physics.

PH 495 or 496* Special Research Problems Credits to be arranged
[Permission of Head of Department and instructor]

Special problems in theoretical and experimental physics assigned to the individual student. Emphasis on modern research methods and preparation of results for publication.

PH 509-510 The Origin and Development of (3-0) (3-0)6
Modern Theories

A critical and detailed examination of the origin and development of theories in modern physics.

PH 511 Classical Mechanics (3-0)3

Selected topics in analytical dynamics, with emphasis on those most applicable to quantum mechanics and field theory.

PH 513-514 Statistical Mechanics (3-0) (3-0)6
[MA 302, PH 324]

Classical statistics, the H-theorem and Boltzmann's transport equation. Quantum statistics, ensemble theory, and the ergodic theorem. Applications to thermodynamics, solid state physics, and nuclear physics.

PH 515-516 Quantum Mechanics (3-0) (3-0)6

Operators and observables. The quantum theory of measurement. Spin and relativistic wave equations. The Dirac theory of the electron, Feynman diagrams, and selected topics in scattering.

PH 518 High-Energy Particles (3-0)3

The physics of high-energy particles, including the so-called strange particles.

PH 523 or 524 Low Temperature Physics (3-3)4
[MA 302, PH 222]

Production of low temperatures; temperature measurement; liquid helium; superfluids and superconductors; paramagnetic salts; magnetic temperature scale; nuclear polarization and alignment; thermal conductivity at low temperatures; the third law of thermodynamics; adiabatic demagnetization.

PH 531

Acoustics

(3-3)4

Not offered in 1962-63.

PH 533 or 534

Crystal Vibrations

(3-0)3

[MA 302, MA 433, PH 472]

Interatomic forces in crystals. The theory of lattice vibrations for one-, two-, and three-dimensional systems. Applications of quantum mechanics and statistical mechanics to crystal systems.

PH 543 or 544

Spectrographic Methods

(2-3)3

[PH 206]

The theory and application of the spectrograph for the qualitative and quantitative analysis of materials. The Bohr theory, quantum mechanics, atomic models, and the theoretical prediction of line and band spectra. In the laboratory individual problems are assigned to the students.

PH 545 or 546

X-Ray Diffraction

(2-3)3

Theory of X-ray production. Absorption. Scattering by electrons and atoms. Crystallographic notation. Lave equations. Determination of crystal structure. For those whose background interests involve fibers, some opportunity for investigation of these is offered in the laboratory work.

PH 547 or 548

**Electron Microscopy and
Electron Diffraction**

(2-3)3

[PH 206, PH 251]

Analogies with optics; electrostatic and magnetic lenses; electron trajectories; solutions of the Laplace and paraxial ray equations; vacuum techniques; the scattering of electrons; electron diffraction: wave properties of the electron, diffraction patterns, crystallographic terminology, reciprocal lattice; replicative, photographic, and other laboratory techniques in electron microscopy and diffraction.

PH 549 or 550

Infrared Radiation

(2-3)3

The laws and theories of black body radiation, including those of Planck, Wien, and Stefan-Boltzmann are thoroughly analyzed. Optical systems and infrared properties of materials are evaluated. Detector systems, including thermal photographic, photoelectric, and photoconductive, are considered. The laboratory experiments are designed to enrich and verify the lecture theories. Experiments include verification of the radiation laws, measurement of optical properties of materials, determination of spectral response and detectivity of detectors, time constant measurements, detector area and detector temperature effects.

PH 533 or 554 Piezoelectricity and Ferroelectricity (3-3)4

Crystallographic bases of piezoelectricity, crystal elasticity, rotated axes, modes of vibration; behavior and interactions of the elastic, dielectric, and piezoelectric coefficients; ferroelectric crystals, domain structure, transitions between phases, free and clamped states; applications of piezoelectric and ferroelectric crystals.

PH 555 or 556 Ion Physics (3-0)3
[PH 353]

A mechanistic approach to the study of ion behavior and associated stability problems in electric and magnetic fields; the development of the hydromagnetic equations from the Boltzmann transport equation and Maxwell's equations; consideration of problems associated with the confinement of a plasma and the extraction of energy therefrom; the measurement of parameters associated with ions in electric and magnetic fields.

PH 561 or 562 Nuclear Physics (3-0)3
[PH 462]

A theoretical course treating the general aspects of nuclear reactions. Alpha and beta decay. Nuclear models and recent advances in nuclear physics.

PH 563 Microwave Spectroscopy (3-3)4
Not offered in 1962-63.

PH 565 Nuclear Resonance Methods (3-3)4
Not offered in 1962-63.

PH 567 or 568 Neutron Diffraction Analysis (3-0)3

The diffraction of neutrons in crystals and its applications in the determination of lattice structures and magnetic moments.

PH 575-576 Problems in Solid State Physics (3-0) (3-3)7

Quantum mechanics and specific heats, lattice energy, elastic coefficients, applications of statistical mechanics, ferroelectric crystals, diamagnetism and paramagnetism, Brillouin zones, Hume-Rothery rules, order-disorder transformations, semiconductors, ferromagnetism and antiferromagnetism, ferrimagnetism, magnet relaxation and resonance, superconductivity, lattice vacancies, diffusion, color centers, excitons, dislocations, and thermal and electrical conductivity at low temperatures.

PH 581 or 582 Information Theory (3-0)3

Information is defined and the identification with entropy made; codes and written and spoken languages are critically examined for information content and redundancy. The Tuller-Shannon formula is used to discuss the

capacity of channels with noise. Autocorrelation techniques are examined and applied. Physical analogs of communications problems are stressed throughout.

PH 583-584 Relativity Theory (3-0) (3-0)6

Invariance of physical laws. Tensor formulation of the special theory of relativity and applications. The general theory of relativity.

PH 585-586 Classical Field Theory (3-0) (3-0)6

The theory of electromagnetic fields. Elements of special relativity. The covariant formulation of Maxwell's equations. Applications such as the classical treatment of the field of moving charges, radiation, scattering, and physical optics. Introduction to gravitational fields.

PH 589 or 590 Quantum Field Theory (3-0)3

Not offered in 1962-63.

Ph 591 or 592 Graduate Thesis Credits to be arranged

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

Plastics

PL 201-202 Plastics Technology I (2-0) (2-0)4

A descriptive subject to acquaint the student with plastics as a class of materials. The history, definitions, classes, properties, and applications of plastics.

PL 301-302 Plastics Technology II (2-2) (2-2)6
[PL 201-202]

Raw materials and manufacturing processes. Methods of processing plastics materials, including compounding, molding, casting, extruding, laminating, fabricating, and finishing. Evaluation and development of typical plastics problems. Laboratory instruction in the processing and fabrication of plastics materials.

PL 401-402 Plastics Technology III (2-3) (2-3)6
[PL 301-302]

Application of plastics as engineering materials. Product, equipment, and mold design. Correlation of composition, processing, and fabrication with product design and applications. Continuation of laboratory instruction in processing, molding, and fabrication.

PL 403-404 Properties of Polymers (4-0) (0-3)5
[Open to seniors only]

Correlation of composition and structure with important engineering properties of plastics; environmental conditioning and effects of types of loading in evaluation of plastics materials; the theory of testing; critical examination of testing techniques, equipment, and standard ASTM methods of evaluating mechanical, thermal, electrical, and optical properties.

PL 411-412 Plastics Seminar (1-0) (1-0)2
[Open to seniors only]

Informal discussions, based on literature study conducted by the individual, of topics in, or related to, plastics engineering.

Social Sciences

SS 102 Foundations of National Power (2-0)2

An analysis of the relationships between the physical and cultural environment on one hand and differentiated political space on the other. Through the study of these relationships the course provides an understanding of the bases for national strategy in times of both peace and war, since the concern of national strategy is to make optimum use of all the resources of a nation to realize national policy.

SS 223-224 The United States Since 1865 (2-0) (2-0)4

A study of the advancement of the American people from the Reconstruction era to the present. With special permission the first semester may be taken alone for credit.

SS 226 Europe Since 1914 (3-0)3

A review of the backgrounds of both World Wars and the postwar periods, with emphasis on such topics as the rise and development of totalitarianism, postwar efforts to establish international agencies, and changes in economic, political, and social institutions.

SS 301 The Government of the United States (3-0)3

The general concepts underlying American national government and the interaction of the executive, legislative, and judicial branches in the formulation and execution of domestic and foreign policies, with special emphasis on the role of parties, interest groups, and international organizations.

SS 303 Psychology I (3-0)3

The place of psychology in the life of the individual and society, with emphasis on the psychological bases of behavior and attitude in their relations to personal, industrial, and community experiences.

SS 304 Psychology II (3-0)3

[SS 303 and permission of instructor]

The interpretation of interpersonal behavior. This subject is organized around group meetings with discussions of cases involving interaction between individuals. Members of the group learn to interpret behavior from observation of the reaction of other members, reading assignments, self analysis, and periodic interviews with the instructor on the member's behavior interpretations.

SS 305 or 306 Sociology (3-0)3

The principles of sociology, including the development of man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 371 or 372 American Civilization to 1865 (3-0)3

A study of the development of national consciousness in America through a review of the evolution of economic, political, and social institutions and their influences upon U. S. culture.

SS 403 Foundations of National Power (3-0)3

[For Advanced AFROTC Cadets only]

An analysis of the relationships between the physical and cultural environment on one hand and differentiated political space on the other. Through the study of these relationships the course provides an understanding of the bases for national strategy in times of both peace and war, since the concern of national strategy is to make optimum use of all the resources of a nation to realize national policy.

SS 459 or 460 International Relations (3-0)3

The state system, national interests, and the controls created to restrain states and maintain international order.

SS 470 **Comparative Modern Governments** (3-0)3

Twentieth-century political thought and the structure and functions of government in democratic and totalitarian systems, with emphasis on the governments of France, Germany, Great Britain, and the Soviet Union.

SS 472 Foreign Policy of the United States Since 1775 (3-0)3

American foreign policy since the founding of the Republic, with particular attention to the influences of both World Wars and the role of the United States in the postwar periods.

SS 477 or 478 Twentieth-Century Russia (3-0)3

The objective of this subject is twofold: to give the student an understanding of the Russian people, the Empire, and the Soviet Union through a study of backgrounds, and to make possible a comprehension of the structure, aims, and methods of the Soviet regime and its present role in world affairs.

SS 479 or 480 The Far East Since 1900 (3-0)3

Basic historical and cultural backgrounds of the peoples of East Asia surveyed as a preface to a study of the economic, political, and social development of the mainland and island states, with emphasis on the interests and policies of European nations and the United States.

SS 481 The Greeks and Western Civilization (3-0)3

Contributions of the ancient Greeks to our culture. The influences of Greek thought, arts, and politics studied through selected readings and discussions in seminar meetings.

SS 482 The Romans and Western Civilization (3-0)3

Roman contributions to western culture and politics, with emphasis on Roman legal and governmental concepts and institutions.

Textile Chemistry

TCH 355* Chemistry and Physics of Fibers (3-0)3

The structure and chemical reactions of linear high polymers of importance in the field of natural and synthetic fibers; the chemical and physical structure of polymers and fibers; the relation of molecular length, orientation, crystallinity, intermolecular attractions, side chains, and flexibility of polymers to the physical properties of fibers; and chemical reactions of polymers and their effects on fibers.

TCH 401* Textile Seminar (2-0)1

Unit operations involved in the manipulations and processing of fibers, yarns, and fabrics.

TCH 403* Textile Testing Seminar (2-0)1

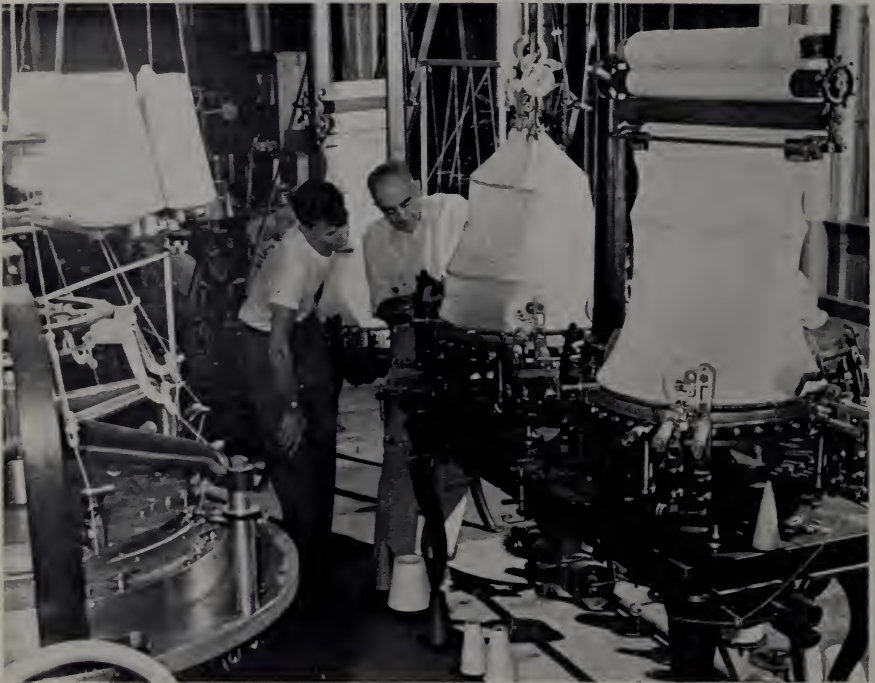
Physical evaluation of fibers, yarns, and fabrics in terms of process control and end use.

TCH 411 Chemical Technology of Finishing I (3-1)3

Conversions of fabrics from the gray state for utility, serviceability, or appearance. Stress is placed both on the chemical phases and on essential engineering principles. Lectures, seminars, and laboratory workshops.



Plastics Technology Demonstration



A Textile Laboratory

TCH 412 Chemical Technology of Finishing II (3-2)4
Continuation of TCH 411.

TCH 422 Chemical Textile Testing (3-0)3

Qualitative and quantitative methods for determining fiber content, finishing agents, and dyestuffs, including optical methods of analysis and evaluation.

TCH 502 Theory of Dyeing (3-4)4

Mechanisms of reactions in the dyeing of fibers which emphasize basic physical and chemical variables affecting equilibria, rates of dyeing, and diffusion. Quantitative studies on the kinetics and equilibria of dyeing reactions are conducted in the laboratory.

TCH 505 Physical Chemistry of Dyeing (3-0)3

Lectures and exercises on the physicochemical principles involved in the application of dyestuffs to textile materials, including both the thermodynamics and kinetics of dyeing.

TCH 541-542 Graduate Thesis Credits to be arranged

An independent investigation of a problem in textile chemistry in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

TCH 555-556 Textile Chemistry Graduate Seminar (2-0) (2-0)4

A series of informal discussions of current problems in research and technology in the textile chemistry field. Special investigations of the literature serve as a source of seminar topics.

Textiles

TE 301 Technology of Fibers (3-3)4
[CH 204]

A study of the important textile fibers, both natural and man-made, in terms of classifications, origins of natural fibers and production of man-made fibers, geographic distribution, marketing, consumption, and fundamental mechanical and chemical properties so that a basis for understanding the relationship of fiber properties to processing and utilization may be grasped.

TE 311 Fundamentals of Yarns (2-3)3

Consideration of the theory of making a yarn from staple fibers. The basic processing steps of opening, cleaning, carding, combing, drafting, and spinning are considered from the viewpoint of the mechanical principles involved independently of the particular fiber machinery system employed.

TE 312 Cotton System Yarns (5-3)6
[TE 311]

A study of the processing of textile fibers using the cotton yarns machinery system. Emphasis is placed upon fundamental aspects of the subject and the integration of this subject with TE 311.

TE 314 Woolen and Worsted System Yarns (5-3)6
[TE 311]

Similar in scope and emphasis to TE 312 except that the woolen and worsted yarns systems machinery is employed.

TE 316 Filament System Yarns (1-1)1
[TE 311]

Concerned with the textile steps in processing the various filament yarns, as delivered by the chemical fiber producers, for use by the weaving and knitting elements of the textile industry.

TE 330 Mechanics of Fabric Design (4-3)5

A study of the fundamental theory and practice relating to the analysis and design of woven structures regardless of the fibers and/or yarns involved.

TE 334 Elements of Textiles: Fabrics (2-3)3

The basic aspects of the production of fabrics by weaving and knitting using common machinery systems.

TE 361 Textile Systems I (4-4)4

The elements of fiber preparation, yarn manufacture by the various common systems, weaving, and knitting presented in an analytical, operational units manner, regardless of the fiber involved. Systems components, interrelationships, and commonness of function as well as the structural analysis, design, and synthesis of yarns and fabrics studied in terms of a mechanical frame of reference. Laboratory time is devoted to demonstrations of basic concepts only.

TE 362 Textile Systems II (4-2)4
[TE 361]

A study and analysis of the processing of fabric from the loom to the finished state, regardless of fabric construction or fiber content, and including design considerations influencing major operational systems of

purification, dyeing or printing, and finishing. Major emphasis is placed on the mechanical engineering aspects of the systems, with the necessary chemical aspects required to supplement this approach.

TE 381 Textile Mechanisms (2-3)3

The basic principles of kinematics as applied to textile machinery. Some of the important topics covered are rolling cylinders and cones, gearing, gear train design, epicyclic gear trains, flexible connectors, cam design, linkages, and related mechanisms.

TE 431 Technology of Woven Fabrics (4-3)5
[TE 330]

Designed to familiarize students with the basic machines and techniques for the production of woven fabrics regardless of the fibers and/or yarns employed, from the preparation of yarns for introduction into a loom to the various loom actions and modifications available for the production of a variety of fabrics. Primary emphasis is upon the mechanical principles employed.

TE 433 Technology of Knitted Fabrics (4-3)5
[TE 330]

Similar in concept and scope to TE 431 except that it is devoted to knitted fabrics. A broad survey of the important types of knitting. Considerable stress is placed on the various stitches and the characteristics of fabrics from each. Starting with flat machines, the work advances through small ribbers, automatic hosiery machines, full-fashioned hosiery machines, underwear machines, and warp knitters. The production, design, and analysis of knit fabrics and the classifications and routines for manufacture of hosiery and underwear are included.

TE 454 Technology of Finishing (4-3)5

Lectures and laboratory workshops in the major engineering and chemical considerations necessary to finish fabrics of wool and wool blends. The engineering aspects are stressed.

TE 455-456 Chemical Technology of Finishing I (2-1) (1-2)4
[CH 202, TE 334]

The major aspects in the conversion of fabrics of wool or wool blends for utility, serviceability, or appearance. Stress is placed on the chemical phases but such engineering aspects are included as are necessary to supplement and process to completion.

TE 457-458 Chemical Technology of Finishing II (2-1) (1-2)4
[CH 202, TE 334]

Similar in concept and scope to TE 455-456 except that it is devoted to finishing fabrics made of cotton and man-made fibers processed on cotton system machinery.

TE 471**Textile Evaluation I****(2-3)3**

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equilibrium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 472**Textile Evaluation II****(2-3)3**

A consideration of basic chemical and optical tools and techniques available to the textile industry for research, development, product control, and end use evaluation. Quantitative and qualitative determination of fiber content, organic and inorganic nonfibrous constituents, evaluation of colorfastness properties, application of the physics of color measurement to dyed textiles, an introduction to microscope optics, and the utilization of microscopy in textile work are among the topics considered.

TE 474**Instrumentation for Textiles****(2-2)3****[EE 204]**

A study of indicating and recording instruments used to measure such common textile process variables as pressure, temperature, humidity, liquid level, fluid flow, etc. Response characteristics of mechanical, electrical, and electronic systems, and process characteristics and their effects upon the selection of the correct mode of control.

TE 482**Application of Scientific Methods to
Textile Processes****(3-0)3****[MA 206, ME 341]**

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483-484 Engineering Design of Textile Structures (3-0) (3-0)6**[MA 205, TE 362]**

This subject correlates engineering properties of textile materials, engineering principles, and textile processing in the design of textile structures with desired properties. The geometry of yarns and fabrics; design of textile structures for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes which the end use imposes; analyses of load-elongation diagrams of textile structural material.

TE 501-502 Structure and Properties of Fibers (3-0) (3-0)6
[Permission of instructor]

The molecular structure and arrangements of molecules in fibers are considered with respect to giving a foundation to the understanding of the physical and mechanical properties and behavior of these textile raw materials. These properties are examined from a fundamental viewpoint so that a sound approach to the technological utilization of fibers in textiles can be established. Such aspects as polymer structure, order, intermolecular forces, and flexibility, as they relate to stress-strain characteristics, viscoelastic behavior, etc., are discussed as well as the effects of environmental conditions on these factors. An introduction is made to the interrelation between fiber properties and yarn and fabric geometry in determining the behavior of textiles.

TE 503 or 504 Technology of Cotton Fibers (2-2)3
[Permission of instructor]

Effects of various chemical, mechanical, and growth modifications of cotton on the chemical, physical, and processing properties of the cotton fiber. Problems are assigned for laboratory evaluation, and a paper for class delivery is required of each student.

TE 511 or 512 Plant Organization: Cotton (2-2)3
System Yarns
[Permission of instructor]

Designed to correlate the various aspects of yarn production using cotton system machinery. Emphasis is placed upon the need for proper balance among the machinery elements for the production of specific yarn types. Consideration of machinery layouts for efficient and economic operation of the total yarn establishment, with stress on the various calculations involved. Considerable use is made of the case history technique of presentation.

TE 513 or 514 Cotton System Waste Processing (2-2)2
[Permission of instructor]

A study of the methods and machinery employed in processing cotton wastes and/or new cotton on waste machinery. Individual student papers on an assigned topic are presented in class.

TE 515 or 516 Plant Organization: Woolen and (2-2)3
Worsted System Yarns
[Permission of instructor]

Similar in concept and scope to TE 511 or 512 except that it is devoted to the utilization of woolen and worsted systems machinery.

TE 517 or 518 Product Quality: Cotton (2-2)2
System Yarns
[Permission of instructor]

Devoted to a study and analysis of product defects in the manufacture of yarns on cotton system machinery. Procedures necessary to avoid the defects are studied, and the diagnostic ability of the student to recognize and remedy defects is developed.

TE 519 or 520 Multifiber Processing: Cotton (2-2)2
System Yarns
[Permission of instructor]

The blending and processing of various fibers utilizing cotton system machinery, with emphasis upon fiber properties and yarn characteristics.

TE 531 or 532 Plant Organization: Fabric (2-2)3
Production
[Permission of instructor]

Similar in concept and scope to TE 511 or 512 and TE 515 or 516 except that the subject pertains to the production of woven fabrics. Plant layout, production, and work loads for various basic woven fabric constructions are considered.

TE 533 or 534 Kinematics of Looms (2-2)3
[Permission of instructor]

Concerned with a study of loom motions, with emphasis upon instrumentation applications for the securing of pertinent information.

TE 535 or 536 Identification and Classification of (2-0)1
Fabrics
[Permission of instructor]

Designed to impart knowledge relative to the important fabric types in use in wearing apparel, home furnishings, and industry. An analytical discussion approach is used so that not only the fabrics may be identified but also the significance of the fabric geometry and properties may be grasped.

TE 537 or 538 Fundamentals of Jacquard Fabrics (1-1)1
[Permission of instructor]

Sketching of original designs as applied to particular Jacquard fabrics, transfer of design to cross-section design paper, choice of weave structure for both the background and foreground, cutting and lacing of cards, and weaving of sample lengths of fabric.

TE 539 or 540 Complex Woven Structures (2-1)2

A study of Leavers lace design and production theory, production machinery, and manufacture. The same aspects of Schiffler embroidery are covered, as well as the fundamentals pertaining to chenille, Wilton, Brussels, tapestry, velvet, and Axminster carpets.

TE 541 or 542 Problems in the Technology of (3-3)3
Knitted Fabrics

[Permission of instructor]

Basically an advanced subject for students interested in the manufacture of knitted fabrics. The student is encouraged to select a particular field from the various sections of the knitting industry and to concentrate on its problems.

TE 543 or 544 Color Theory (2-3)3

[Permission of instructor]

The study of color from a subjective viewpoint utilizing the Munsell Color System, with primary stress placed upon the relation of color to fabric design, structure, and utilization.

TE 545 or 546 Weaving Laboratory (0-3)1

[Permission of instructor]

Designed to provide additional time for the student in the weaving laboratory so that greater familiarization with the operation of various loom mechanisms may be acquired.

TE 571 or 572 Textile Microscopy (2-3)3

[Permission of instructor]

The principles involved in the use of the microscope for the qualitative and quantitative estimation of the morphological, physical, and chemical properties of textile materials.

TE 573 or 574 Mechanical Testing of Textiles (2-3)3

[Permission of instructor]

Thickness and compressional measurements, stress-strain-time phenomena of viscoelastic textile materials, Vibroscope theory and techniques, yarn uniformity, thermal determination, and friction evaluation are among the major topics covered. Emphasis is placed on current literature search assignments and the preparation of a student paper on a selected topic within the scope of the subject.

TE 581 or 582 Textile Plants Organization (2-2)3

[Permission of instructor]

A study of the numerous factors at the management level leading to the establishment of a textile plant. Location finding, labor supply, ma-

materials supply, transportation, community relations, and machinery balance are considered for various types of textile processing plants. The case history technique is used to advantage in this subject.

TE 591 Methods of Research (2-0)1

Required of all graduate students in Textile Engineering during their thesis year. A seminar to familiarize the student with the philosophy of research.

TE 592 Thesis Seminar (2-0)1

Required of all graduate students in Textile Engineering during their thesis year. Devoted to problems in the preparation and presentation of research work, with illustrative material drawn from thesis work in process.

**TE 593-594 Graduate Thesis Credits to be
arranged**

Each graduate student in Textile Engineering is required to submit a thesis which shows ability and originality in the solution and presentation of a research project.

THE GRADUATE SCHOOL

INTRODUCTION

The Lowell Technological Institute Graduate School, founded in 1935, offers the degree of Master of Science in the following fields:

- Chemistry
- Electrical Engineering
- Leather Chemistry
- Paper Technology
- Physics and Mathematics
- Textile Chemistry
- Textile Technology

In addition the School offers a program leading to the Doctor of Philosophy degree in Chemistry with options in organic and physical chemistry.

Because of the varied objectives of the graduate students, each specific course of study is arrived at through consultation with the student's graduate adviser or advisory committee. Each program includes an original thesis.

ADMISSION

General Admission

To be eligible for admission to the Graduate School, an applicant must have received a bachelor's degree in an acceptable four-year course in which he has maintained a uniformly high scholastic rating. Both the quality and quantity of previous training are considered. Selection of applicants admitted is based as far as possible upon their ability to pursue graduate work of high quality.

Special Student Status

An applicant who meets the general admission requirements but who wishes to concentrate on specific subjects or special research programs may request special student status. Acceptance is contingent upon the consent of the instructor in charge of each subject to which admission is desired, and the work does not lead to a degree.

Normally a special student may not change his status to that of a student working for a graduate degree. If a special student wishes to work for a degree, he must apply in writing to the Director of the Graduate School. If the application for change in status is approved, all of the credit earned as a special student may not necessarily be allowed for degree credit.

Provisional Status

An applicant for admission who is unable to meet all the requirements for general admission may be accepted provisionally if he satisfies the department in which he wishes to enroll that he is probably able to pursue graduate studies successfully.

The status of a provisional graduate student may be changed to that of a graduate student upon demonstration of his ability to pursue graduate studies successfully as measured by the completion of his first semester's work with a scholastic rating equal to that required for graduation. (See Requirements for Graduation. M.S. p. 144; Ph.D., p. 150.)

Application Procedure

Applications may be obtained from the Office of the Graduate School. They should be completed and returned to the Director of the Graduate School not later than June 1 preceding the fall term in which the applicant wishes to enroll. Applications must be supported by letters from at least two persons qualified to judge the ability of the applicant to carry on graduate work and research. The letters should be sent directly from these persons to the Graduate School.

Two sets of transcripts of all undergraduate records (and graduate, if any) must be sent directly to the Office of the Graduate School by the institutions which the applicant has previously attended. All transcripts must be official, with appropriate seals and signatures. Records, descriptions of subjects, and letters must be in English. Each subject must be described in terms of content, scope, number of hours per week, and number of weeks duration. Lecture and laboratory time should be properly distinguished. If a catalogue giving such descriptions in English is available, the subjects taken may be clearly marked in a copy sent to the Graduate School.

Credit may be given for graduate subjects taken at other colleges if the grade received is at least B and if these subjects were not used in earning another degree. Not more than 10 credit hours for the master's degree or more than 22 credit hours for the doctor's degree may be transferred. No transfer credit can be offered for the thesis requirement for any graduate degree. Transfer credit for subjects taken at other colleges before initial enrollment at Lowell Technological Institute must be cleared within four weeks after the student's first registration. No transfer credit for such subjects is given after this period.

In addition to making application for admission and having transcripts and letters sent, the applicant must take the Graduate Record Aptitude Test and have the results sent to the Director of the Graduate School. Information regarding the Graduate Record Aptitude Test may be obtained from Educational Testing Service, 20 Nassau Street, Princeton, N. J., or Box 27896, Los Angeles 27, Cal., whichever office is nearer to the applicant.

Because most subjects are presented in lecture form, students from other countries should have a reasonably fluent command of the English language before applying for admission.

Except in unusual circumstances, applications are acted upon and the applicant is notified of the decision by July 1. Foreign applicants are urged to make application as early as possible so as to leave enough time for visa and other arrangements to be made.

EXPENSES

Tuition (per year)	
U.S. citizens who are residents of Massachusetts	\$200
U.S. citizens who are residents of other states	300
All others	550
Student Activity and Insurance Fee (per year)	43

In addition, every graduate student is required to bear the cost of binding at least two copies of his thesis for the Institute's files. Some divisions may require more than two bound copies. The doctoral candidate must also pay to have his thesis microfilmed. Students are not permitted to register for thesis work until these fees have been paid at the library.

FELLOWSHIPS

Teaching Fellowships

A limited number of part-time instructorships are available to qualified students working toward a graduate degree. Stipends range from \$1500 to approximately \$2500, depending on the nature of the appointment, and reappointment in succeeding years is contingent upon satisfactory performance of duties. Appointees are expected to carry up to a half-time teaching load primarily involving supervision of undergraduate laboratories and review sections. Application forms may be obtained from, and must be filed prior to April 30 with, the Director of the Graduate School.

Research Fellowships

A few research fellowships are available to qualified students through industrial grants. Appointees are expected to devote full time to study and research. Application should be made at the time of applying for admission to the Graduate School and prior to April 30. Appointments are made about June 1 for the next academic year.

National Science Foundation Cooperative Graduate Fellowships

The Institute is a participant in the National Science Foundation's Cooperative Graduate Fellowship Program. These fellowships are awarded on the basis of ability. Candidates must be citizens of the United States

on or before March 1 following the submission of their applications and must be admitted to full graduate status by the Institute prior to beginning their fellowship tenures.

The stipend provided by the NSF for Cooperative Graduate Fellows is \$2200-\$3000 for those on a tenure of 12 months and \$1650-\$2250 for those on a tenure of nine months. In addition to the stipend, the NSF pays all tuition and fees to the Institute.

One of the requirements for making application for an NSF Fellowship is to take the Educational Testing Service Graduate Record Examinations (Aptitude Test and one Advanced Test in the area of specialization). Because the deadline for making application for the fellowships is in early November, it is important to make arrangements to take these tests early.

MASTER OF SCIENCE DEGREE PROGRAMS

Chemistry

This program provides opportunity for advanced study and research training in chemistry, both general and specialized. Provision also is made for the student to elect certain advanced subjects in related fields of mathematics, physics, and engineering.

Subject Requirements—Of the 20-credit minimum, exclusive of thesis and seminar, required in listed subjects (see Requirements for Graduation) a minimum of 15 credits must be taken in chemistry. Of these not more than 12 credits may be taken in approved undergraduate subjects, although normally credit is not allowed for undergraduate subjects in the major field of specialization, e.g., organic, physical, inorganic. Recommended subjects include CH 403-404*, CH 423-424*, CH 431-432*, CH 443-444*, and all 500 courses in chemistry. Each graduate program must include subjects in organic chemistry, inorganic chemistry, and physical chemistry. All students must take CH 507-508, Chemistry Seminar. The remaining credits (five or more) may be taken in chemistry or in a related field such as physics, mathematics, or engineering. All subjects must be approved by the student's advisory committee.

Language Requirements—The student must demonstrate his ability to read technical German.

Advisory Committee—The development of the student's program of study is the responsibility of an advisory committee consisting of three members from the faculty of the Division of Chemistry and Applied Chemistry. This committee is appointed by the Director of the Graduate School upon the recommendation of the division chairman and includes the thesis supervisor.

Thesis Examination—Each candidate for the Master of Science degree in Chemistry, upon completion of his thesis, must present himself for an oral examination in the field of his thesis before an examination committee

appointed by the Director of the Graduate School and consisting of his advisory committee and any additional faculty members desired by the Director. While only members of the examination committee and the Director of the Graduate School may conduct the examination, all faculty members may attend. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the Director of the Graduate School at least one month prior to the close of the last semester. Each student has the right to one re-examination within a period of one year.

Electrical Engineering

This graduate program offers to a limited number of selected students opportunity for individualized work in the more advanced areas of electronics with emphasis on analytic methods of analysis and synthesis.

Leather Chemistry

Opportunity for graduate research in Leather Chemistry is provided through this program. In general only those students either possessing the B.S. degree in Chemistry or having a strong background in chemistry are acceptable as candidates for the M.S. degree.

The curriculum in Leather Chemistry is similar to that required for the M.S. degree in Chemistry, and subject requirements are identical. No language requirement is involved, but CH 507-508, Chemistry Seminar, must be taken each semester the student is in residence. Opportunity is provided for conducting research in chemistry as applied to the composition and technology of leather, and laboratory facilities for processing and testing leather are available.

Thesis Examination—Upon completion of the thesis, each candidate for the degree of Master of Science in Leather Chemistry must present himself for an oral examination in the field of his thesis to an examination committee appointed by the Director of the Graduate School. This examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester.

Paper Technology

The graduate program in Paper Technology is for the purpose of giving advanced work in papermaking, paper-converting, or allied fields.

The Paper Technology Department will consider graduate students from three different sources:

- (a) graduates of the Lowell Technological Institute B.S. Paper Technology course;
- (b) paper technology B.S. and M.S. graduates of other schools;
- (c) general B.S. and M.S. engineering graduates with no previous paper training.

Students with the backgrounds given under (a) and (b) should be able to complete the work in one academic year. Students in group (c) should be able to complete the degree requirements in two academic years.

A graduate student in Paper Technology will take approximately 50% of his graduate subjects (including thesis) in the Paper Technology Department. The balance may be taken as electives related to the paper field and approved by the Department.

The graduate subjects offered are:

CH	423-424*	Advanced Organic Chemistry	(3- 0) (3- 0)6
PA	501-502	Graduate Thesis	(0-12) (0-12)8
PA	505-506	Advanced Papermaking and Paper Converting	(2- 6) (2- 6)8
PL	411-412	Plastics Seminar	(1- 0) (1- 0)2

Physics and Mathematics

The graduate program in Physics and Mathematics provides an opportunity for advanced study and the development of research capacity in physics or mathematics or both. The laboratories of the department are well set up for investigations in crystal physics and other aspects of solid state physics, with excellent equipment in X-rays, spectroscopy, and electron microscopy. Equipment in nuclear physics is constantly being added.

Subject Requirements—Of the 20-credit minimum, exclusive of thesis, required in listed courses (see Requirements for Graduation) 15 credits must be taken in physics and mathematics. The remaining credits (five or more) may be taken in a related field. Of the total credits at least 12 must be in subjects numbered 500 and above. A reasonable and consistent program of study is prepared by the student and his advisory committee. This committee consists of two or more members from the faculty of the Division of Physics and Engineering Science, one of whom is the thesis supervisor. The committee is appointed by the Director of the Graduate School upon the recommendation of the Chairman of the Division of Physics and Engineering Science. Entering students who are found to be deficient in any areas of the undergraduate curriculum in Physics may be required to take appropriate courses in that curriculum.

Language Requirements—The student must demonstrate his ability to read technical German or Russian.

Thesis Examination—Each candidate for the Master of Science degree in this department, upon completion of his thesis, must present himself for an oral examination in the field of his thesis to an examination committee appointed by the Director of the Graduate School and consisting of his advisory committee and any additional faculty members desired by the Director. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the Director of the Graduate School at least one month prior to the close of the last semester. Each student has a right to one re-examination within a period of one year.

Textile Chemistry

The graduate program in Textile Chemistry provides opportunity for advanced study and research in chemistry as applied to textiles and textile auxiliary agents. Formal subjects and research facilities are provided for training in fiber science and in the chemistry of the various processing operations applied to fibers, yarns, and fabrics, including dyeing, finishing, and fiber modifications.

The M.S. degree in Textile Chemistry normally requires two years for completion except in those instances where the student possesses previous training in this field sufficiently extensive to meet departmental standards. In the following suggested curriculum, those subjects designated by a dagger represent minimum degree requirements:

First Semester		
CH 503†	Interpretation of Data	(3-0)3
TCH 355*	Chemistry and Physics of Fibers	(3-0)3
TCH 401*	Textile Seminar	(2-0)1
TCH 403*	Textile Testing Seminar	(2-0)1
TCH 411	Chemical Technology of Finishing I	(3-1)3
Second Semester		
CH 334	Colloid Chemistry	(3-0)3
CH 512†	Physical Chemistry of Surface-active Agents	(2-0)2
TCH 412	Chemical Technology of Finishing II	(3-2)4
TCH 422	Chemical Textile Testing	(3-0)3
TCH 502†	Theory of Dyeing	(3-4)4
Third Semester		
TCH 505†	Physical Chemistry of Dyeing	(3-0)3
TCH 541†	Graduate Thesis	5
TCH 555†	Textile Chemistry Graduate Seminar	(2-0)2
	Elective	3
Fourth Semester		
CH 538†	Rheology	(2-0)2
TCH 542†	Graduate Thesis	5
TCH 556†	Textile Chemistry Graduate Seminar	(2-0)2

Recommended electives include CH 501 and CH 568.

Textile Technology

This graduate program is offered to qualified students in the field of textiles, with primary emphasis upon either the engineering or physical aspects of the field. Ample opportunity is afforded for study and research in the physical and mechanical properties of fibers and textile structures and methods of evaluating them. Work at an advanced level on the structural design of textiles, processing principles, and manufacturing equipment is also available. Applicants should have a B.S. degree in Textile Engineering or Technology, Mechanical Engineering, or Electrical Engineering. Applicants with degrees in other areas, however, are given consideration.

Subject Requirements—The program for each student is arranged to meet the student's needs and interests. Of the 20-credit minimum, exclusive of thesis, required in listed subjects (see Requirements for Graduation) at least 10 credits must be taken in the area of textiles, and not more than six credits may be taken in other fields. A minimum of five additional credits must be taken in the field of engineering.

Thesis Examination—Each candidate for the Master of Science degree in Textile Technology, upon completion of his thesis, must taken an oral examination in the field of his thesis. This examination is conducted by a committee appointed by the Director of the Graduate School which must include the thesis supervisor and advisers of the candidate and any additional faculty members desired by the Director. Any faculty members may attend, but only members of the examination committee may conduct the examination. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the semester in which the student expects to be a candidate for the degree. Application to take the examination must be filed by the student with the Director of the Graduate School at least one month prior to the close of the designated semester. If the student fails the oral examination, he has the right to one re-examination within a period of one year. Failure in the re-examination requires the satisfactory completion of a new thesis subject and the accompanying oral examination.

MASTER OF SCIENCE DEGREE REQUIREMENTS

Term of Residence

Applicants with sufficient background in their chosen field of concentration normally require one academic year of residence to complete the requirements for the master's degree. Those with no background require a minimum of two years of residence.

Graduates of other colleges usually need more than one academic year to fulfill the degree requirements, even though they majored as undergraduates in their graduate field of specialization.

All requirements for the master's degree must be completed within five years after the student's entrance. Extension of time beyond this limit may be granted only with joint approval of the student's adviser (or advisory committee), his department head, his division chairman, and the Director of the Graduate School.

Candidacy for the Master's Degree

Admission to a master's degree program does not indicate that the student is a candidate for the degree. A student enrolled in a graduate program who has established an acceptable scholarship record and who has completed half of the required program may be considered as a candidate for the degree.

Requirements for Graduation

To be recommended for the Master of Science degree a candidate must:

1. Complete a course of study approved by the department in which he has been enrolled. The approved course of study must have a minimum of 30 credit hours, including thesis. A minimum of 20 credit hours must be spent in listed subjects, and the program should have no fewer than five credit hours of thesis work.
2. Complete a thesis (original research or other investigation, optional with the department) approved by the department in which he has been enrolled, and successfully pass any oral or written examinations on his thesis required by the department at the time his thesis is submitted for final approval. The only grades given for thesis work are S (satisfactory) and U (unsatisfactory).
3. Maintain residence for at least one academic year.
4. Maintain a B average in all work in formal subjects offered for the degree. The lowest grade acceptable for graduate credit is C. No plus or minus grades are used for graduate subjects. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work, but which are taken during his enrollment as a graduate student, must be passed with a grade of at least C; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.

DOCTOR OF PHILOSOPHY DEGREE PROGRAM

Chemistry

The doctoral program in Chemistry is designed to provide both advanced knowledge and research training in chemistry, particularly in the fields of organic and physical chemistry and polymer science, with emphasis in the field of textiles for those so desiring.

Plan of Program

The doctoral degree normally requires from three to four years of study beyond the bachelor's degree or a minimum of two to three years beyond the master's degree.

The plan of study pursued by each student is dependent on individual requirements and is developed through conference with his advisory committee or, pending its appointment, with his temporary adviser.



Illustrious Honorary Alumnus



Action on the Court

Immediately upon entrance, each student is given a set of three evaluation examinations administered by the Division of Chemistry and Applied Chemistry in the fields of organic chemistry, physical chemistry, and combined inorganic-analytical chemistry. The results of these examinations serve as a guide for the student and advisory committee in planning the program of study.

The initial part of the student's program, normally completed at the end of two years of study, is devoted to formal course work. His first year is usually given to subjects in the major branches of chemistry in preparation for his qualifying (candidacy) examinations. The second year is devoted primarily to advanced courses in a special field of concentration in preparation for the major examinations.

The second and final part of the program is devoted principally to research leading to the doctoral thesis. However, the student is encouraged to begin research as early as possible in his program of study.

Upon entrance to the doctoral program, each student is assigned an advisory committee. This committee is appointed by the Director of the Graduate School, based upon recommendation by the Chairman of the Division of Chemistry and Applied Chemistry, and consists of at least three members of the faculty. Of these at least two must be from the faculty of the Division of Chemistry and Applied Chemistry. One member of the committee representing the student's major field of interest serves as temporary chairman. After the student has selected his thesis supervisor, the temporary chairman of the advisory committee is replaced by the thesis supervisor, who then serves as permanent chairman.

Examinations

Qualifying Examinations—Three written qualifying examinations are given by the department, each involving one full day. These examinations cover the fields of organic chemistry, inorganic chemistry, and inorganic-analytical chemistry. Before the student can be admitted to candidacy for the doctorate, he must pass all three examinations.

Qualifying examinations in all fields are given twice each year, in September during or before the week of registration and in January following the examination period for the first semester. All three qualifying examinations must be taken not later than the beginning of the third semester of graduate study (normally in September of the second year), although any one or all may be attempted earlier. In cases of failure, repeat examinations must be taken in the following examination period. All qualifying examinations must be passed before the beginning of the fourth semester in the doctoral program, and no examination may be repeated more than once.

The comprehensive examination is in two parts, a written examination lasting one day and covering the field of the major, and an oral examination in defense of a proposition.

The written examination is given once a year in September. It should be taken as soon as possible after completion of the bulk of course work in listed graduate subjects in the field of specialization. However, it must be taken not later than the beginning of the fourth year of study in the doctoral program. Where it is necessary to carry less than the normal credit load of 12+ per semester, the student must apply for extension beyond this deadline to the chairman of the division through the chairman of his advisory committee.

The proposition represents a thesis in miniature without laboratory work. With the aid and advice of his advisory committee the student selects a subject suitable for investigation, completes a literature survey, outlines the method of approach, and suggests possible results and conclusions. He is then required to defend his proposition by oral examination. The examination is conducted by the student's advisory committee and other faculty members of the department.

Prior to the oral examination and at least one month before the scheduled date of the written comprehensive examination, the student must file with the chairman of his advisory committee three written copies of his proposition, presented in the form generally prescribed for a thesis. The oral defense of the proposition is presented at a time following the written comprehensive examination, and permission to take the oral examination is contingent on first passing the written test.

The request to take both qualifying and comprehensive examinations must be initiated by the student. The request is made to the advisory committee, and the chairman of that committee then submits a written recommendation to the division chairman that the examination be given. The examination schedule is published well in advance of the date set, and the student must file the request with his advisory committee at least one month before the scheduled date. The deadline normally is 5 P.M. on the last day of classes preceding the Christmas recess for the January examinations and 5 P.M. on the last day of classes in the second semester for the September examinations.

Language Examinations—A candidate for the doctorate must demonstrate by examination ability to read technical literature in two foreign languages. One foreign language must be German. The second language is generally French or Russian. Proficiency in English is a requirement for foreign students, and the department reserves the right to establish this proficiency by examination if such action is indicated.

Course Offerings and Distribution

As a basis for the candidacy examinations the following core of subjects is recommended for the first-year students in the doctoral program:

CH 423-424*	Advanced Organic Chemistry	(3-0) (3-0)6
CH 431-432*	Advanced Physical Chemistry	(3-0) (3-0)6
CH 443-444*	Advanced Inorganic Chemistry	(3-0) (3-0)6
CH 564	Organic Qualitative Analysis	(1-6)3

If results from the diagnostic examinations indicate adequate background in any of the above subjects, substitution by a more advanced subject in the 500 series is recommended. Full graduate credit is allowed in the 400 subjects listed above, but credit is not allowed in advanced 400 courses representing the field of the major, even though these may be recommended. Additional subjects in chemistry or in the field of the minor may be taken in the first year if desired, provided the prerequisites are met.

In the second year, subjects supporting concentration in specific fields are available as follows:

Organic Chemistry

CH 513	Physicochemical Methods	(3-0)3
CH 521-522	Physical Organic Chemistry	(3-0) (3-0)6
CH 524	Organic Chemistry of Macromolecules	(3-0)3
CH 525	Chemistry of the Carbohydrates	(3-0)3
CH 527-528	Stereochemistry	(2-0) (2-0)4
CH 561-562	Advanced Organic Synthesis	(2-0) (2-0)4
CH 565	Metal-Organic Compounds	(3-0)3
CH 566	Heterocyclic Chemistry	(3-0)3

The core of subjects recommended for majors in organic chemistry includes CH 521-522, CH 527-528, CH 561-562. Majors in organic chemistry must also meet a requirement in physical chemistry either by taking the sequence CH 431-432*, CH 537, CH 539-540; or CH 537, CH 539-540, depending upon the student's background as indicated by the diagnostic examinations.

Physical Chemistry

CH 531-532	Chemical Thermodynamics	(3-0) (3-0)6
CH 533	Statistical Mechanics for Chemists	(3-0)3
CH 534	Quantum Mechanics for Chemists	(3-0)3
CH 535-536	Advanced Topics in Physical Chemistry	(3-0) (3-0)6
CH 538	Rheology	(2-0)2
CH 539-540	Theoretical Chemistry	(3-0) (3-0)6

Seminar

During each year of residence the student is required to attend and to participate in CH 507-508, Chemistry Seminar, (1-0)(1-0)2.

Majors and Minors

Students may major in organic chemistry or in physical chemistry. The prospective candidate, moreover, is expected to supplement his training in the major field of interest by electing a minor. To avoid overspecialization, this minor is normally selected in a field other than chemistry, although it may include polymer science. The minor may be divided between two fields and should represent a minimum of 12 credits.

Students wishing to minor in polymer science may select subjects from the following offerings:

CH 403-404 *	Chemistry of High Polymers (laboratory optional)	(3-0) (3-0)6
CH 524	Organic Chemistry of Macromolecules	(3-0)3
CH 568	Principles in the Technology of Organic Construction Materials	(3-0)3
PL 403	Properties of Polymers	(4-0)4

DOCTOR OF PHILOSOPHY DEGREE REQUIREMENTS

Term of Residence

Only work done during the regular academic year from September to June is counted toward residence credit. A minimum of one full academic year of study in residence is required of all candidates. A full year constitutes not less than 36 credit hours of work. Semesters in residence should be consecutive if possible.

All requirements for the doctorate must be completed within seven years after the student's entrance and within four years after admission to candidacy. Extension of time beyond this limit may be granted only with the joint approval of the student's advisory committee, his department head, his division chairman, and the Director of the Graduate School.

Candidacy for the Doctorate

To be admitted to candidacy for the doctorate, a student must:

1. Complete the first year's core of advanced subjects in physical chemistry, organic chemistry, inorganic chemistry, and physico-chemical methods and have a satisfactory record in undergraduate training, graduate seminar, and collateral reading.
2. Pass the qualifying examinations which test his general knowledge. One day each is devoted to an examination in the following areas: organic chemistry, physical chemistry, and combined inorganic-analytical chemistry.
3. Fulfill the language requirements.
4. Secure the approval of his advisory committee and the division chairman.

When these requirements have been fulfilled, the division chairman notifies the Director of the Graduate School in writing and recommends that the student be placed on the list of candidates for the Ph.D. degree. Admission to candidacy in no way guarantees the granting of the degree.

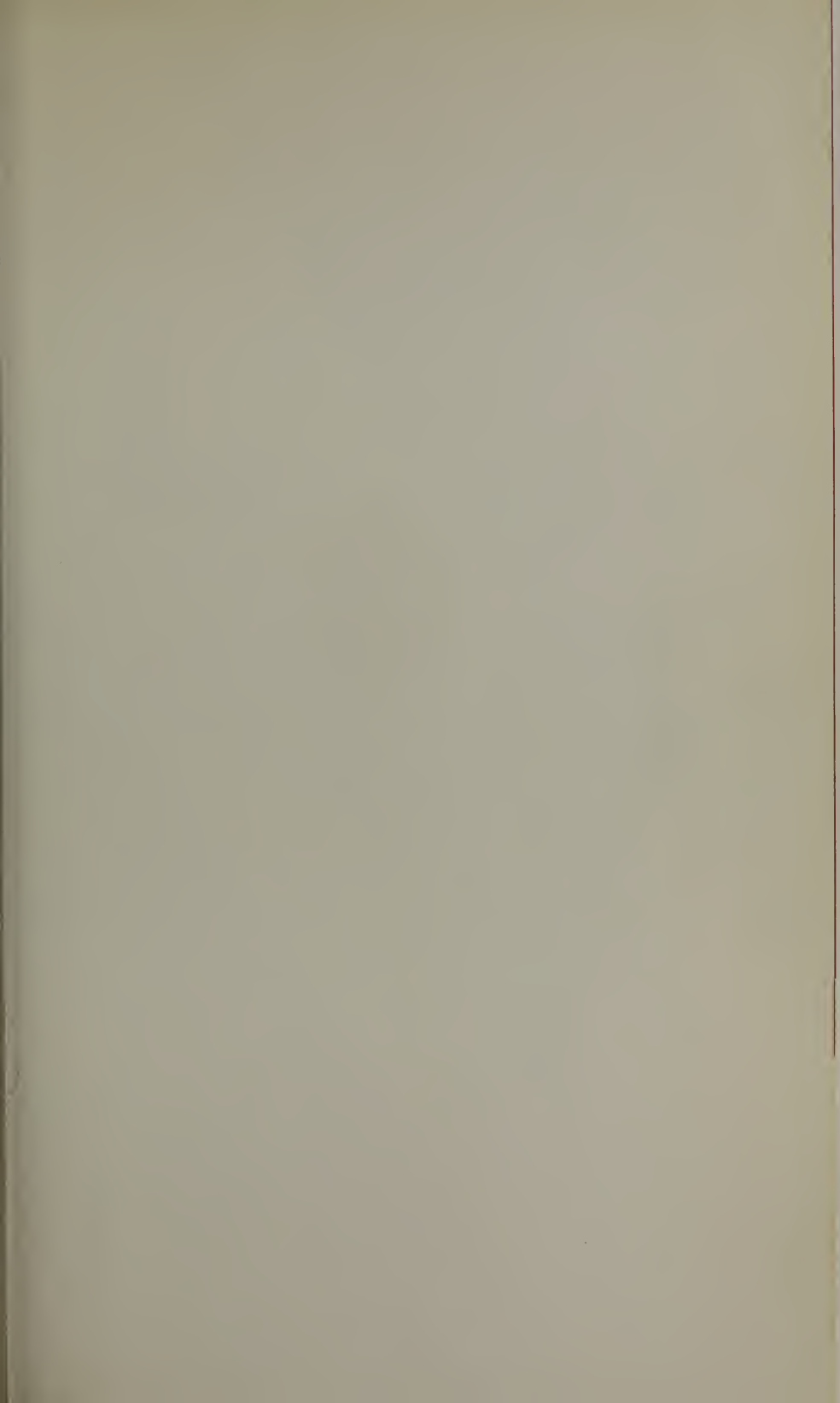
Requirements for Graduation

To be recommended for the Doctor of Philosophy degree, a candidate must:

1. Satisfy the residence requirements.
2. Pursue an approved program of study that includes the satisfactory completion of at least 90 credit hours beyond the bachelor's degree, or equivalent. At least half of these credits must be in formal course work exclusive of seminars or thesis.
3. Maintain a B average in all work in formal subjects offered for the degree. The lowest grade acceptable for doctoral credit is C. No plus or minus grades are used for graduate subjects. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work, but which are taken during his enrollment as a graduate student, must be passed with a grade of at least C; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.
4. Demonstrate satisfactory reading ability in German and one other language (preferably French or Russian). Foreign students may under certain circumstances substitute their native tongue for one of these languages. Both language examinations must be passed prior to advancement to candidacy and before extensive work on the thesis is begun.
5. Pass the qualifying examinations for candidacy.
6. Pass the major examinations in the field of concentration. These examinations primarily test the student's knowledge in his special field of concentration and draw heavily on knowledge gained during his second full year of study in that particular area. They are given only when substantially all of the formal course work has been completed, normally at the end of the second full year (fourth semester). The major examination is in two parts. The first part is written and extends over a period of one day. It tests the student's broad knowledge in his specific field. The second part of the major examination is oral and tests the student's aptitude for research and his ability to organize and to develop a research problem. The examination takes the form of the defense of a proposition. The student selects a problem with the approval of his advisory committee.
7. Complete a satisfactory thesis. The doctoral thesis is designed to permit the student to demonstrate his ability to conduct original and independent research work. Results of the thesis investigation should constitute a definite contribution to knowledge in the field of

specialization and should be suitable for publication. The field of the thesis investigation should be selected as soon as possible after admission to the graduate program, and the subject of the thesis must be approved by the advisory committee. As soon as the subject has been selected, the student must make his choice known to the department head, who in turn notifies the Graduate School so that the list of theses in progress may be kept current. The thesis subject must be filed not later than two weeks after the student has been admitted to candidacy. The thesis normally constitutes about half of the total credit requirement and, as a rule, requires three to four semesters of full-time work.

8. Pass a thesis examination. This is an oral defense of the student's thesis before the faculty of the Department of Chemistry.
9. Satisfy all requirements as to tuition and fees.





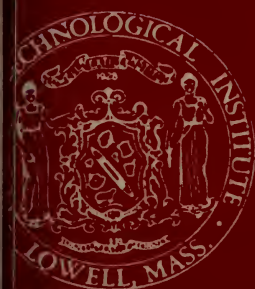
BULLETIN OF THE
LOWELL
TECHNOLOGICAL
INSTITUTE

Lowell, Mass.

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1963-1964





Aerial View of the Campus



Alumni Memorial Library

LOWELL TECHNOLOGICAL INSTITUTE

1963-1964 CATALOGUE

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LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Massachusetts

Established 1895

Operated by the Commonwealth of Massachusetts

Engineering and scientific curricula leading to B.S., M.S., and Ph.D. degrees

Member of, or approved by, American Chemical Society, American Council on Education, College Entrance Examination Board, Engineers' Council for Professional Development, Massachusetts Department of Education, New England Association of Colleges and Secondary Schools

Total enrollment—4900

Day Division—1600

Evening Division—2500

Summer School—800

Men and women students from 18 states and 25 countries

Tuition: \$200 for U. S. citizens who are residents of Massachusetts

\$300 for U. S. citizens who are residents of states other than
Massachusetts

\$550 for all others

L.T.I. Research Foundation conducts research and development work for government and industry.

The main campus lies between Mass. route 113 and the VFW Highway along the bank of the Merrimack River, one-half mile north of the center of Lowell, 25 miles north of Boston.

Office hours: 8:30 A.M.—5:00 P.M., Monday through Friday

Telephone number: 454-7811 (Area Code 617)

The Lowell Technological Institute Bulletin is published quarterly and consists each year of a Day School Catalogue, an Evening Division Catalogue, and two technical papers.

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The Board of Trustees reserves the right to waive, at its discretion, any of the rules and regulations stated herein and to change any of the subjects or curricula, or portions thereof, without prior notice.

ACADEMIC CALENDAR, 1963-1964

September 10, Tuesday	Freshman Orientation Week begins. Registration of graduate students begins.
September 12, Thursday	Registration of sophomores.
September 13, Friday	Registration of seniors and juniors.
September 16, Monday	Classes begin.
September 20, Friday	Last day to register for new classes.
October 11, Friday	Last day to drop classes without penalty.
November 11, Monday	Veterans Day. Institute closed.
November 27, Wednesday, 12 Noon	Thanksgiving recess begins.
December 2, Monday	Classes resume.
December 19, Thursday, 12 Noon	Christmas recess begins.
January 6, Monday	Classes resume.
January 16, Thursday, 2 P.M.	Freshman examinations begin.
January 17, Friday	Other first-semester examinations begin.
January 23, Thursday	End of first semester.
January 28, Tuesday	Registration of freshmen.
January 30, Thursday	Registration of sophomores and graduate students
January 31, Friday	Registration of juniors and seniors.
February 3, Monday	Classes begin.
February 7, Friday	Last day to register for new classes.
February 28, Friday	Last day to drop classes without penalty.
March 20, Friday, 12 Noon	Spring recess begins.
March 30, Monday	Classes resume.
April 20, Monday	Patriots Day observance. Institute closed.
May 15, Friday	Last day for submitting graduate theses.
May 23, Saturday	Second-semester examinations begin.
June 5, Friday	End of second semester.
June 7, Sunday	Commencement.

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Charles R. Mingins, A.B. (Wesleyan University), Ph.D. (Cornell University), Prof., Chairman of Division of Physics and Engineering Science, and in charge of Departments of Nuclear Science and Engineering, Physics and Mathematics, and Textile Technology

Howard K. Moore, A.B., A.M., Ph.D. (Boston University), Prof., in charge of Department of Languages and Literature, and Director of Libraries

Paul J. Murphy, B.S.E.E. (Massachusetts Institute of Technology), Asst. Prof., Electrical Engineering

Thomas J. Murphy, A.B. (Boston College), M.B.A. (Harvard University), Instr., Economics and Management

Henry A. Myers, B.A. (Swarthmore College), M.A. (Boston University), Asst. Prof., Languages and Literature

Christopher Noble, B.S. (U.S. Naval Academy), M.S. (Harvard University), Asst. Prof., Mechanical and Textile Engineering

Raymond O. Normandin, A.B. (St. Anselm's College), M.S. (Boston College), Asst. Prof., Plastics Technology

Winford S. Nowell, B.M.E. (Northeastern University), Prof., Textile Technology

Gerard W. O'Connor, A.B. (Harvard University), A.M. (Boston University), Asst. Prof., Languages and Literature

A. James Oliver, B.S. (Boston University), M.Ed. (Boston State College), Asst. Prof., Physical Education

Andrew A. Ouellette, B.S. (Brown University), Prof., Physics and Mathematics

George B. Parrent, Jr., B.S. (Bradley University), M.A. (Boston University), Ph.D. (University of Manchester, England), Lect., Electrical Engineering

Robert J. Peirent, B.S., M.S. (Lowell Technological Institute), Assoc. Prof., Textile Chemistry

Robert W. Perry, B.S. (Worcester Polytechnic Institute), M.A. (Columbia University), Lect., Physics and Mathematics

Arthur Petrou, B.S. (University of New Hampshire), Asst. Prof., Mechanical and Textile Engineering

David H. Pfister, B.S., M.S. (Lowell Technological Institute), P.E. (Massachusetts), Assoc. Prof., Textile Technology

James B. Pierce, B.S. (Thiel College), M.S., Ph.D. (Case Institute of Technology), Assoc. Prof., Chemistry

Ronald M. Pike, B.S., M.S. (University of New Hampshire), Ph.D. (Massachusetts Institute of Technology), Prof., Chemistry

Clarence J. Pope, B.S. (Clemson College), M.S. (Lowell Technological Institute), Assoc. Prof., Physics and Mathematics

James E. Powers, B.S., M.S. (Lowell Technological Institute), Asst. Prof., Electrical Engineering

Howard H. Reynolds, A.B. (Harvard University), Sc.D. (Massachusetts Institute of Technology), Prof., in charge of Department of Chemical Engineering and Paper Engineering

John J. Riley, A.B., M.A. (Boston University), Instr., Languages and Literature

John R. Robertson, A.B. (Bowdoin College), A.M. (Harvard University), Prof., Chairman of Division of General Studies and in charge of Department of Social Sciences

Kenneth L. Rogers, B.S. (University of Maine), P.E. (Massachusetts), Assoc. Prof., Mechanical and Textile Engineering

Frederick A. Rojak, B.S.E.E. (Pratt Institute), M.S. (Lowell Technological Institute), Asst. Prof., Electrical Engineering

Vittoria Rosatto, B.S. (Massachusetts School of Art), Prof., Textile Technology

Major John A. Rubino, Jr., USAF, B.S. (St. Louis University), Asst. Prof., Air Science

Charles L. Saccardo, B.S. (Northeastern University), Instr., Economics and Management

Dominick A. Sama, S.B., S.M., Sc.D. (Massachusetts Institute of Technology), Director of the Graduate School, and Prof., Mechanical and Textile Engineering

Carleton E. Sawyer, B.A. (Bowdoin College), M.S. (University of Maine), Instr., Physics and Mathematics

Allen Scattergood, A.B. (Columbia University), Ph.D. (Princeton University), Prof., Chemistry

Bernard Selikson, B.S., M.S., Ph.D. (New York University), Lect., Physics and Mathematics

James C. Sethares, B.S.E.E. (University of Massachusetts), S.M.E.E. (Massachusetts Institute of Technology), Lect., Electrical Engineering

Bernard Shapiro, B.S. (Lowell Technological Institute), S.M. (Massachusetts Institute of Technology), Instr., Economics and Management

John H. Skinkle, S.B. (Massachusetts Institute of Technology), M.S. (Lowell Technological Institute), Prof., Textile Chemistry

Gerald Smithson, B.S. (Brown University), M.S. (Tufts University), Prof., Electrical Engineering

Carl A. Stevens, B.S., M.S. (Tufts University), Sc.M. (Brown University), Ph.D. (Boston University), P.E. (Massachusetts), Prof., in charge of Department of Electrical Engineering

Harry E. Stockman, E.E. (Stockholm Technical Institute), M.S. (Royal Institute of Technology, Sweden), Sc.D. (Harvard University), Prof., Electrical Engineering

Albert Stone, Jr., B.A., LL.B. (University of Texas), M.A. (University of Houston), Ph.D. (Harvard University), Assoc. Prof., Languages and Literature

Philip G. Tays, B.S. (Lowell Technological Institute), Instr., Electrical Engineering

Henry E. Thomas, B.T.E. (Lowell Technological Institute), P.E. (Massachusetts),
 Prof., Plastics Technology
 George J. Toscano, B.S. (Northeastern University), C.P.A., Asst. Prof.,
 Economics and Management
 Martin Trust, B.M.E. (Cooper Union), S.M. (Massachusetts Institute of
 Technology), Asst. Prof., Mechanical and Textile Engineering
 Emery I. Valko, Ph.D. (University of Vienna, Austria), Fellow of the Textile
 Institute (British), Assoc. Prof., Chemistry (on leave of absence)
 David P. Wade, B.S. (Lowell Technological Institute), Instr., Electrical
 Engineering
 Capt. Warren M. Walker, USAF, A.B. (University of Missouri), Asst. Prof.,
 Air Science
 Francis R. Walsh, B.S., M.A. (Boston University), Instr., Social Sciences
 Tso-Chou Wang, Dip., D.Eng. (Technische Hochschule, Germany), Assoc. Prof.,
 Mechanical and Textile Engineering
 Joseph W. Waterman, B.S. (University of Vermont), M.B.A. (Boston Uni-
 versity), Instr., Economics and Management
 Earl J. Watt, A.B., A.M. (Harvard University), Assoc. Prof., Languages and
 Literature, and Coordinator of Special Services
 A. Edwin Wells, B.T.E. (Lowell Technological Institute), M.Ed. (Boston
 University), P.E. (Massachusetts), Prof., Mechanical and Textile
 Engineering
 Albert T. Woidzik, B.S. (Lowell Technological Institute), P.E. (Massachusetts),
 Asst. Prof., Textile Technology
 Francis T. Worrell, B.S. (University of Michigan), M.S., Ph.D. (University of
 Pittsburgh), Prof., Physics and Mathematics
 Waldo W. Yarnall, B.S. (University of Vermont), Director of Athletics

Professors Emeriti

Hermann H. Bachmann
 Herbert J. Ball, S.B., B.C.S., Sc.D., Fellow of the Textile Institute (British)
 Horton Brown, B.S.
 William G. Chace, Ph.B., M.S.
 Harold C. Chapin, A.B., A.M., Ph.D.
 Lester H. Cushing, A.B., Ed.M.
 James G. Dow, A.B.
 Elmer E. Fickett, B.S., Sc.D.
 Russell M. Fox
 C. Leonard Glen
 Martin J. Hoellrich
 Nathaniel E. Jones
 James H. Kennedy, Jr., B.T.E., M.S.
 Gilbert R. Merrill, B.T.E.

ADMINISTRATIVE ASSIGNMENTS

Admissions Office

Richard W. Ivers, B.A., M.Ed., *Director of Admissions*
Arthur F. Haley, B.S., M.Ed., Ed.D., *Admissions Officer*
Maurice W. Harrison, B.T.E., *Admissions Officer*
Mary E. Perkins, *Secretary*

Assistant to the President's Office

Kleonike Bentas, *Secretary*

Buildings and Power

George F. Abodeely, LL.B., *Administrator*
Ralph E. Frost, *Chief Engineer*
Joseph A. Nerney, *Maintenance Foreman*

Bursar's Office

Wilfrid J. Brodeur, *Bursar*
Patricia J. Gallagher, *Bookkeeper*
Charles F. Johnson, *Property Officer*
John L. Sayer, *Bookkeeper*
Mary C. Sullivan, *Clerk*
Russell H. White, *Clerk*

Dean of Faculty's Office

Theresa D. Leblanc, *Secretary*

Dean of Students' Office

Barbara Jean Maccaron, *Secretary*

Division of Chemistry and Applied Chemistry

Mona M. Davis, *Secretary*
Rosemary Cambria, *Secretary*
Ray E. MacAusland, *Chemical Storekeeper*

Division of Evening Studies

Ann V. Lenihan, *Secretary*
Rose A. Connerton, *Clerk*

Division of Physics and Engineering Science

Joan Cinq-Mars, *Secretary*
Eleanor M. McKenna, *Secretary*
Leo F. Patenaude, *Electronics Equipment Supervisor*

Graduate School Office

Mary A. Gomes, *Secretary*

Guidance

John J. MacLaughlan, Ph.B., A.M., *Director*

Health Services

Arlene D. Gordon, *R.N.*

(Local physicians and specialists as required)

Libraries

Howard K. Moore, A.B., A.M., Ph.D., *Director*

Joseph V. Kopycinski, B.S., M.S., M.S. in Library Science, *Librarian*

Charles F. Donaldson, *Library Assistant*

Ruth B. Fitzgerald, *Library Assistant*

Mary P. Frascarelli, *Library Assistant*

Eleanor T. Lessard, *Library Assistant*

Vera Boyd Meehan, B.S., *Library Assistant*

Ann V. Pendergast, *Library Assistant*

June E. Traverse, *Library Assistant*

Placement Office

Michael J. Taylor, *Director of Placement*

President's Office

Helen G. Flack, S.B., *Executive Secretary*

Elizabeth P. Kennedy, *Secretary*

Receptionist

Lorraine I. LeDoux

Registrar's Office

Walter M. Drohan, A.B., A.M., *Registrar*

Nora M. MacBrayne, *Secretary*

Mabel M. Murphy, *Clerk*

Catherine P. Ouellette, *Clerk*

Special Services

Earl J. Watt, A.B., A.M., *Coordinator of Special Services*

Barbara A. Browne, A.B., *Director of Information*

Mary A. Gomes, *Secretary*

Summer School

Ernest P. James, B.T.C., M.S., *Director*

GENERAL INFORMATION

History

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry.

In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of leather chemistry, paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, physics, physics and mathematics, nuclear science, nuclear engineering, and industrial management.

In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to the Lowell Technological Institute. The Institute grants Bachelor of Science, Master of Science, and Doctor of Philosophy degrees.

Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

Accreditation

The Institute is a member of the Senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends full accreditation to the curricula in electrical, mechanical, and textile engineering, and the chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races and religions are represented in the enrollment. Although the majority of its students are men, the Institute is coeducational.

Campus

The Institute is located 25 miles north of Boston in Lowell, Massachusetts, a city of nearly 100,000, long famous as a textile center and more recently noted for its increasingly diversified industries. The 25-acre campus, situated on the Merrimack River, includes eleven main buildings, among them the library, an auditorium-administration building, six classroom-laboratory buildings, two residence halls, and a power plant. A \$4,500,000 nuclear center and a \$2,120,000 physical education building are under way.

Alumni Memorial Library

The library, dedicated to alumni of the Institute who served in World Wars I and II and the Korean conflict, was erected in 1951 by the Alumni Association through contributions from alumni and friends. Besides a book stack capacity of 80,000 volumes, it contains student activity offices and alumni headquarters and houses one of the world's most complete collections of textile books as well as numerous special collections in the fields of paper, leather, and plastics. It also serves as a depository for U. S. government publications and is available to industrial concerns through its Industrial Corporate Membership program.

Equipment

Laboratory equipment used in the instructional and research programs of the Institute is valued at more than \$10,000,000. It includes such varied apparatus as an electron microscope, analog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, paper, plastics, leather, and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Students from other countries are advised to start the application procedure not less than 12 months in advance of the expected date of enrollment.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Director of Admissions.

Application Procedure

A candidate for admission should:

1. Complete the first two pages of the admission application form.
2. Attach a certified check or money order in payment of the application deposit of \$10 (see Student Expenses for explanation).
3. Submit the entire application form to the office of his secondary-school principal, with a request that the office fill out pages 3 and 4 and mail the completed application directly to the Director of Admissions.
4. Make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test which is required of all applicants for admission to the freshman class at the Institute.

Applicants for admission who are in the upper 20% of their high-school class scholastically may be admitted by the Chairman of the Committee on Admissions prior to their completion of entrance examinations.

Late applicants will be specifically advised with respect to entrance examinations by the Director of Admissions.

5. Undergo a complete health examination by his family physician. The physician must return to the Director of Admissions, in duplicate, on forms provided by the Institute a certificate of good health, indicating the date of the examination.

6. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of his place of residence.

All admission records, once submitted, become the property of the Institute and cannot be returned.

7. Make formal application for a scholarship with the Institute, if he desires scholarship aid.

8. Upon receipt of his letter of admission, submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll.

A personal interview with the Director of Admissions is strongly recommended. The Office of Admissions is open Monday through Friday from 8:30 A.M. to 5:00 P.M. throughout the year. *Appointments for interview should be made in advance.*

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must be a graduate of a secondary school approved by the New England Entrance Certificate Board, the Regents of the State of New York, or a board of equal standing.

2. He must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	$\frac{1}{2}$ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the deficiency in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least $15\frac{1}{2}$ units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

In evaluating credits offered for admission, the Institute is guided primarily by the quality of the scholastic record of the applicant and by his promise on grounds of intellect and character. Therefore, an applicant whose preparation has not followed the normal pattern with respect to the accumulation of unit credits should not hesitate to apply for entrance, provided that the quality of his scholarship gives evidence of ability to do college work and provided that he is recommended by his school.

Admission with Advanced Standing

Transfer students must file a formal application for admission to the Institute and must answer "yes" to question 6(b) on page 1 of the application. This must be done prior to April 1 of the year in which the student wishes to matriculate.

Transfer credit is given for courses satisfactorily completed with a grade of C or better which are the equivalent in quality and scope of those given at the Institute. Final decision on transfer credit rests with the appropriate division chairman and the Dean of Students.

Transfer students who have not taken the Scholastic Aptitude Test of the College Entrance Examination Board for matriculation at their previous college may be required to do so. It is the responsibility of the transfer student to ascertain from the Admissions Office the procedure to be followed prior to his acceptance.

Advanced credit will not be given any student after his matriculation.

Students from Other Countries

The Institute accepts every year foreign applicants in each class in numbers up to 5% of that class. In all respects, the admission procedure for foreign students is the same as that required of U. S. citizens. They are urged, however, to have the transcript of their secondary-school and/or college records, as well as all other application materials, submitted, *in English, not less than twelve months in advance of the expected date of enrollment.* All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U. S. students.

To facilitate their adjustment to campus life, all freshman male students from other countries are required to live in the Institute's residence halls and are assigned to rooms shared by U. S. students. Students must supply their own towels, sheets, pillows and pillowcases, and blankets or may subscribe to a laundry service. Bedding, as well as clothing, should be suitable for a climate in which temperatures normally fall well below the freezing point during the winter months.



Coronation of Ball Queen



Student-Faculty Seminar

STUDENT HOUSING AND SERVICES

Residence Halls

All male students not living at home are required to live in the residence halls on campus unless they are excused in writing by the Dean of Students. Excuses are reviewed at the beginning of each semester and may be cancelled, should conditions warrant.

Application for permission to occupy other living quarters must be made on special blanks available at the Office of the Dean of Students. An application for this purpose must be filed annually by every student desiring off-campus residence. All new students (incoming freshmen, transfer, special, or graduate students) must file before September 1, and all regularly enrolled students must file before June 1, of the year in which off-campus residence is desired.

Permission is accorded in cases where the student lives a reasonable distance from the Institute, where financial hardship would be involved through living in a residence hall, or where the student is a member of a fraternity which maintains a fraternity house. Also considered in granting permission is the academic year of the student (graduate, senior, junior, sophomore, freshman).

Although rooms are furnished by the Institute, students must take care of them. Each student must supply his own sheets, pillow and pillowcases, blankets, towels, and personal linens or may subscribe to the laundry service provided to all resident students at cost. Each occupant of a room is responsible for damage which may result to furniture or equipment.

Room assignments in residence halls are made for the full academic year. A change of room is not permitted except in rare instances and may be accomplished only after formal application for the change is approved by the Dean of Students.

Rental charge for each residence room is made for the academic year. While the charge covers occupancy only during periods when the Institute is in regular session, it may, at the discretion of the Institute, be extended to include vacation periods.

Room assignments are made as equitably as possible and in the order that applications are received. The Dean's Office supplies a list of approved rooming houses where students may reside who are unable to be placed in residence halls.

Students are cautioned to make no legal agreements nor sign residence leases with persons outside the Institute.

Dining Hall

A cafeteria and a snack bar are available in the residence halls, but use of campus dining facilities is not compulsory.

Health Service

The dispensary, in Smith Hall, is in the charge of a registered nurse for eight hours each school day. Students receive first-aid treatment at the dispensary and are advised as to the best procedure to take in case of illness. Medical services are available to students 24 hours daily. There are three excellent modern hospitals in the immediate vicinity of the Institute. Students must bear their own medical fees and hospital charges.

If a student requires emergency surgical treatment, every effort is made to communicate with his parent or guardian. Failing this, such action is taken as appears to be necessary in the interest of the student.

Accident insurance during the academic year is compulsory and is included in the activity and insurance fund. Health insurance also is available, on a voluntary basis, through the Office of the Dean of Students.

Guidance

The guidance program, under the supervision of the Dean of Students' Office, starts with the admissions procedure and continues throughout the freshman year. During registration, a testing program is conducted, results of which are used to supplement the student's scholastic record and his College Entrance Board examinations. During Orientation Week, the freshman attends a series of lectures whose purpose is to help him in his adjustment to college requirements.

Each freshman is assigned by the Director of Guidance to a faculty member who is his primary contact with other phases of the guidance program. This adviser, who is also a freshman instructor, arranges individual consultations and provides advice and referral help in scholastic, financial, personal, or health problems.

Other phases of the guidance program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sessions. In the second semester of the freshman year a series of lectures is offered to help the student to become aware of the curricula at the Institute and to determine what course he should elect for the next three years.

Guidance in the upper classes is generally conducted in scholastic matters by the head of the department concerned and in personal problems by the Director of Guidance.

STUDENT REGULATIONS

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups of students but to provide a pattern so that a large student body may live and work harmoniously together.

A student may be dropped from the rolls whenever it is considered in the best interests of the Institute.

Attendance

All students must attend all classes, although a limited number of absences is permitted. Attendance is taken at all classes. Students charged with unexcused absences, particularly immediately before and after holiday and vacation periods, are subject to disciplinary action.

Disciplinary Action

Disciplinary action may be in the form of censure, restriction, suspension, or dismissal, according to the measure of an offense. Whenever such action is taken, notation of the penalty is made a part of the permanent record of the student.

Classification of Students

The status of "clear" is accorded a student with no deficiencies on his record through his last completed semester provided he maintains a 1.7 cumulative average.

The status of "deficient" is accorded a student if his total cumulative average falls below 1.7, if he is on scholastic probation with an average of less than 1.3, or if at any time he has not cleared a grade of F in a subject.

Grading System

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

A+	4.3	(97-100)	C	2.0	(73-76)
A	4.0	(93-96)	C—	1.7	(70-72)
A—	3.7	(90-92)	D+	1.3	(67-69)
B+	3.3	(87-89)	D	1.0	(63-66)
B	3.0	(83-86)	D—	0.7	(60-62)
B—	2.7	(80-82)	F	0	(below 60)
C+	2.3	(77-79)			

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than

one semester is obtained in the same manner as the computation for the rating of a single semester.

Dean's List

The Dean's List is composed of students who have a semester rating of 3.0 or higher, with no current failures.

Probation

A student is placed on probation when his semester rating is below 1.3. The probationary period covers the entire semester following the issuance of the semester rating which placed the student on probation.

A student on probation may not represent the Institute in any public function and may not hold class or other offices during his term of probation.

A student with a rating of less than 1.3 for two consecutive semesters is dropped from the Institute for at least one semester. The student should plan to take courses at some other accredited college before applying for readmission.

If a student receives a semester rating below 0.7, he is automatically dropped from the Institute without benefit of a probationary period.

Scholastic Reports

Reports of scholastic standing are compiled at the end of each semester, and formal notification of each student's status is made at that time.

REQUIREMENTS FOR GRADUATION

In order to be recommended for the baccalaureate a student must satisfy the following minimum requirements:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in a major subject.
2. Earn a cumulative rating of 1.7 or above for the entire period at the Institute.
3. Fulfill the residence requirement of one academic year.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors—graduation with a rating of at least 3.0 but less than 3.3 for the entire period of study at the Institute;

With High Honors—graduation with a rating of 3.3 or higher for the entire period of study at the Institute;

With Highest Honors—graduation as the highest ranking student in the class and with a rating of 3.7 or higher, contingent upon the completion of at least six semesters of work at the Institute.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening Division are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION DEPOSIT..... \$10

This is payable by certified check or money order and is filed with the Director of Admissions at the time of application.

1. If the applicant is accepted for admission and is duly enrolled as a student at the Institute, the entire amount of this deposit is credited toward his tuition charges on the day of registration.
2. If the applicant is not accepted for admission, the entire amount of the deposit is refunded.
3. If the applicant is accepted for admission but does not choose to enroll, no refund is made.
4. If the applicant is accepted for admission but is called to duty in the armed forces of the United States, he is entitled to a refund of the entire amount of the application deposit.
5. The Institute requires the prepayment of 50% of the first semester's tuition within 30 days of the date upon which the applicant is accepted for admission. For Massachusetts residents this amounts to \$50. This prepayment is forfeited if the student fails to register at the Institute. In rare instances, such as sickness which would prevent the applicant from enrolling, this rule may be waived by the Dean of Students.

TUITION

	(per year)
U. S. citizens who are residents of Massachusetts	\$200
U. S. citizens who are residents of states other than Massachusetts	\$300
All others	\$550

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule: (per semester)

U. S. citizens who are residents of Massachusetts..	\$10.00 per cr. hr.
U. S. citizens who are residents of states other than Massachusetts.....	\$15.00 per cr. hr.
All others.....	\$27.50 per cr. hr.

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community claimed as legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.
2. The residence of a minor follows that of the parents, unless the minor has been emancipated. A minor student who has been emancipated must also present documentary evidence of emancipation.
3. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.
4. The residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.
5. The residence of a wife follows that of the husband.
6. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.
7. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.
8. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

Note: Wherever mentioned above, the word *residence* means *legal domicile*.

ROTC DEPOSIT..... \$25

This deposit covers loss of, or damage to, uniforms or equipment used for ROTC instruction and is required of all students enrolled in that program. The entire amount, minus charges, is refunded upon completion of ROTC requirements. If, at any time, the charges against a student exceed the

amount on deposit, he must pay the charges and make an additional deposit of \$25.

ACTIVITY AND INSURANCE FUND..... \$43

Each student enrolled in 10 or more total credit hours must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

RESIDENCE HALLS

The residence hall charge is at the rate of \$600 per room for the academic year, this sum to be divided equally among all occupants of the room (two to four students). One-half of the charge is payable by each occupant at the beginning of each semester.

LATE REGISTRATION FEE..... \$5

A student who does not complete his registration (including the payment of all fees) by the close of the registration period must pay this additional fee.

AUDITING FEE..... \$5/credit hour

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Students.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay \$5 per credit hour to audit a course and must obtain permission from the Dean of Students.

COMMENCEMENT FEE..... \$15

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap and gown, invitations, printing, and any other expenses approved or directed by the President.

OFFICIAL TRANSCRIPT FEE..... \$1/copy

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of \$1 per copy is made for each additional transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

All raw stock and yarn furnished to students and all productions of the Institute remain or become its property, except by special arrangement. Each student, however, is allowed to retain specimens of yarn or fabrics that he has produced, if they are mounted and tabulated in accordance with the requirements of the department. Departments may retain such specimens of students' work as they desire.

Laboratory equipment may not be removed from the premises except by special permission.

REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks		Refund Rate
At least	But less than	
0	2.....	80%
2	3.....	60%
3	4.....	40%
4	5.....	20%
5 and over	None

SUMMARY OF EXPENSES PER YEAR

Tuition

U. S. citizens who are residents of Massachusetts.....	\$200
U. S. citizens who are residents of states other than Massachusetts	\$300
All others.....	\$550

Residence halls..... **\$600 per room,**
divided equally among occupants (2 to 4)

Student activity and insurance fund.....	\$ 43
ROTC deposit.....	\$ 25
Books, supplies, and related miscellaneous expenses (approximate)	\$100

FINANCIAL AID

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the scholarships are renewable annually for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are for a specified period of time.

At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Director of Admissions before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for the test, candidates must also make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Albany Felt Company Scholarship

One annual grant of \$500 to a freshman entering the Institute is made by the Albany Felt Company. Each recipient is given an opportunity for summer employment at the company while in college.

Alumni Association Scholarships

The L.T.I. Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is maintained. Funds for these scholarships are derived from the following sources:

Stephen E. Smith Scholarship Fund

James T. Smith Fund

Arthur A. Stewart Memorial Scholarship Fund

Warwick Chemical Foundation in memory of Walter Nowicki

Berkshire Hathaway, Inc. Scholarships

A number of scholarships covering tuition and living expenses for four years are offered in Textile Engineering by Berkshire Hathaway, Inc., Providence, R. I. Male employees and sons of employees only are eligible. Students interested should contact Berkshire Hathaway, Inc., 704 Hospital Trust Building, Providence, R. I.

Russell L. Brown Scholarship, donated by Davis and Furber Machine Company

This scholarship is open to a student who plans to major in Textile Engineering. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipend is \$300. Appointments are for one year only but are renewable.

Admiral Carl Espe Scholarship

This \$200 scholarship is awarded to the male student presenting the best exhibit in Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute.

Joseph Kaplan Memorial Scholarship

This \$250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools.

City of Lowell Scholarships

The City of Lowell provides a total of five scholarships every two-year period through competitive examination to residents of Lowell, Mass., who are enrolled in the entering freshman class at the Institute. The amount of each scholarship is \$200, and each is renewable provided satisfactory scholastic grades are maintained.

Lowell Sun Charities Scholarship Fund

Through this fund, established by Lowell Sun Charities, Inc., one or two Greater-Lowell residents are eligible for full tuition scholarships, renewable annually. Selection is based upon evidence of good moral character and high scholastic standing.

Commonwealth of Massachusetts Scholarships

Twenty scholarships of \$250 each are available annually to residents of the Commonwealth of Massachusetts who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and the scholarships are renewable on the condition that satisfactory grades are maintained.

Paper Engineering Department Scholarships

Five scholarships, each amounting to \$2000 over the four-year period, are available to incoming freshmen who plan to enroll in the Paper Engineering program. Scholarship holders receive annual stipends of \$500 provided they maintain good academic standing.

Present contributors to this scholarship program include the following:

Carter, Rice, Storrs & Bement, Inc.
Crane & Company, Inc.
Crocker, Burbank & Co., Association
Dennison Manufacturing Company
Erving Paper Mills
Fraser Paper Ltd.
International Paper Company
Ludlow Corporation
Nashua Corporation
Oxford Paper Company
Paper Management Association, Connecticut Valley Division
Riegel Paper Corporation
Tileston & Hollingsworth Company
S. D. Warren Company

Sylvan I. Stroock Scholarship, donated by S. Stroock & Co., Inc.

A \$500 scholarship is awarded each year on the basis of scholarship, financial need, leadership, and promise of success in textile fields from funds established by S. Stroock & Co., Inc.

Science Count-Down Scholarship

A one-year tuition scholarship is available annually to a student who has won first place in Science Count-down, the televised science quiz for Massachusetts eighth-grade pupils, cosponsored by the Institute and WBZ-TV, the Westinghouse Broadcasting Company television station in Boston.

United Elastic Corporation Scholarships

Scholarships of \$250 are available through the United Elastic Corporation to students in textiles. Preference is given to employees or their families, or to residents of communities where plants are located. Especially preferred are native New Englanders. Recipients must agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. They

are renewable annually under the usual conditions. Applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, Lowell, and Littleton, Mass.; West Haven, Conn.; and Stuart, Va.

Western Electric Fund Scholarship

This scholarship, covering the cost of tuition, books, and fees for one year, is available to an undergraduate in an engineering program. Selection is based upon need and ability.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

AVAILABLE TO UPPERCLASSMEN ONLY

Allied Chemical Corporation Scholarship

This grant of \$500 plus tuition, given by the Allied Chemical Corporation, is awarded to a worthy upperclassman majoring in Textile Engineering.

Arthur Besse Memorial Scholarship

The Arthur Besse Memorial Trust awards a \$500 scholarship each year to a student majoring in textiles and planning to continue in that industry after graduation. The award is based on need, scholarship, and qualities of character and leadership, and it is renewable under the usual academic conditions.

Boston Paper Trade Association Scholarships

Two scholarships, each for \$150, are open to sophomores, juniors, and seniors enrolled in Paper Engineering who are residents of New England. Awards are based on scholarship and character.

Chemstrand Corporation Scholarship

A scholarship of \$500 is available to a superior, deserving student enrolled in Textile Engineering. Donor is the Chemstrand Corporation.

DeBell-Richardson Scholarship

DeBell-Richardson, Inc., the D. & R. Pilot Plants, Inc., and John M. DeBell have established a scholarship for a student majoring in Plastics Technology. It is awarded on the basis of scholastic success, extracurricular activities, and financial need.

Dixie Cup Scholarship

The Dixie Cup Division of American Can Company of Easton, Pa., has established a scholarship in the amount of \$500 per year. Students majoring in Chemical Engineering, Electrical Engineering, Mechanical Engineering, Paper Engineering, or Plastics Technology are eligible to apply, and selection is based on scholastic achievement, financial need, and extracurricular participation. The Company provides summer employment for the student holding the scholarship.

Foster Grant Scholarship

The Foster Grant Company, Inc. of Leominster, Mass., makes available on a one-year basis a tuition scholarship to a deserving student in Plastics Technology who is a resident of Massachusetts. Preference is given to a sophomore living in the Leominster area; however, if there are no applicants from that area, another candidate may be chosen. Scholarship, personality, and over-all student contribution to extracurricular activities are the general criteria used in selecting the recipient.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of \$75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

Ralph E. Hale Scholarship

A scholarship of \$250 every year is awarded to a student at the completion of his junior year in the Textile Chemistry curriculum. It was established by the Northern New England Section of the American Association of Textile Chemists and Colorists in memory of Ralph E. Hale, 1951 Chairman-elect of the Section and a 1931 graduate of L.T.I.

New England Paper Merchants Association Scholarship

A \$100 scholarship is open to a sophomore, junior, or senior in Paper Engineering who is a resident of New England. It is awarded on the basis of scholarship and character.

NOPCO Chemical Company Scholarship

The NOPCO Chemical Company of Newark, N. J., has established two \$250 scholarships open to students majoring in Chemical Engineering, Chemistry, Paper Engineering, or Plastics Technology who have proved themselves scholastically and who are active in extracurricular programs.

Society of Plastics Engineers Scholarship

A scholarship is granted annually by the Eastern New England Section of the Society of Plastics Engineers, Inc. to an upperclassman majoring in Plastics Technology.

Jacob Ziskind Memorial Scholarship Fund

Through a fund established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes, scholarships are awarded annually and are renewable under the usual conditions. The scholarships cover tuition, books, supplies, and related expenses. Seniors, juniors, and sophomores who have demonstrated high scholarship, financial need, and qualities of good character and leadership are eligible. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

FELLOWSHIPS

Teaching Fellowships

A limited number of part-time instructorships are available to qualified students working toward a graduate degree. Stipends range from \$1500 to approximately \$2500, depending on the nature of the appointment, and reappointment in succeeding years is contingent upon satisfactory performance of duties. Appointees are expected to carry up to a half-time teaching load primarily involving supervision of undergraduate laboratories and review sections. Application forms may be obtained from, and must be filed prior to April 30 with, the Director of the Graduate School.

Research Fellowships

A few research fellowships are available to qualified students through industrial grants. Appointees are expected to devote full time to study and research. Application should be made at the time of applying for admission to the Graduate School and prior to April 30. Appointments are made about June 1 for the next academic year.

The following research fellowships are available to graduate students in Chemistry and are usually awarded to students in the final stages of the doctoral program:

Allied Chemical Corporation Fellowships

Stipend \$2200. Tuition and fees included.

Research Corporation Fellowships

Stipend \$2200. Tuition and fees not included.

National Science Foundation Cooperative Graduate Fellowships

The Institute is a participant in the National Science Foundation's Cooperative Graduate Fellowship Program. These fellowships are awarded on the basis of ability. Candidates must be citizens of the United States on or before March 1 following the submission of their applications and must be admitted to full graduate status by the Institute prior to beginning their fellowship tenures.

The stipend provided by the NSF for Cooperative Graduate Fellows is \$2200-\$3000 for those on a tenure of 12 months and \$1650-\$2250 for those on a tenure of nine months. In addition to the stipend, the NSF pays all tuition and fees to the Institute.

One of the requirements for making application for an NSF Fellowship is to take the Educational Testing Service Graduate Record Examinations (Aptitude Test and one Advanced Test in the area of specialization). Because the deadline for making application for the fellowships is in early November, it is important to make arrangements to take these tests early.

Textile Salesmen's Association of New York Fellowship

A graduate fellowship in textiles is awarded by the Textile Salesmen's Association of New York, based on academic accomplishment and demonstrated ability. The award is limited to full-time students working toward the M.S. degree in Textile Technology who plan to continue working in the field of textiles in this country after graduation.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of \$10 per quarter the first year and \$20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

National Defense Education Loans

The National Defense Education Act offers loans up to \$1000 to needy students. Repayment begins one year after graduation, unless military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3%, beginning with the first

payment. Repayments may be made over a 10-year period. A 50% forgiveness clause is included for students who enter the field of elementary- or secondary-school teaching for a period of five years.

Geigy Loans

Geigy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, Textile Chemistry, Paper Engineering, or Leather Chemistry. The fund operates under the same conditions as the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

AWARDS

Awards are made annually at an Honors Convocation conducted by the Scholarship and Awards Committee. A few awards are made at Commencement.

American Association of Textile Chemists and Colorists Book Prize.

This is awarded to the outstanding graduating senior in the Textile Chemistry course and includes a junior membership for one year in the A.A.T.C.C. The recipient is recommended by the Division of Chemistry and Applied Chemistry. The academic standing of the candidate is an important factor in the decision.

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

ACS Student Affiliate Chapter Award. A plaque is presented annually by the LTI Student Affiliate Chapter of the American Chemical Society to the outstanding senior majoring in Chemical Engineering or Chemistry, based upon academic performance and demonstration of research capability.

ASTME Award. The Merrimack Valley Chapter, American Society of Tool and Manufacturing Engineers awards \$100 to a member of the Student Chapter of the ASTME who is high in scholastic standing and in need of financial assistance.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, sponsored by the Student Council, is given to the senior who has made the greatest extracurricular contribution to the Institute during his four years of college.

Department of Physics and Mathematics Awards. Handbooks are presented annually by the Chemical Rubber Company to the outstanding freshman in the physics program and the outstanding freshman in the mathematics program.

Ben Faneuil Award. An annual award of \$100 is made by Mr. Ben Faneuil of The Chelsea Industries, Chelsea, Massachusetts, to the sophomore majoring in Plastics Technology with the highest cumulative average.

Jacob K. Frederick Memorial Award. Omicron Pi Fraternity makes an annual award of \$50 in memory of Professor Jacob K. Frederick to a freshman, based on scholastic achievement and extracurricular participation. The award is applicable to the recipient's tuition in the ensuing academic year.

Barnett D. Gordon Award. An award of \$250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, a member of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of \$100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New England Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Engineering selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in chemistry.

Phi Psi Award. This award is given to a member of the graduating class who is outstanding in scholastic attainment, leadership, initiative, personality, loyalty, and courtesy.

President's Medal. This award is made to the student who is graduated *With Highest Honors* for the most distinguished academic record in his class.

Radio Station WLTJ Award. The staff of the student-operated radio station WLTJ awards a plaque annually to a member outstanding for conspicuous service and furtherance of the goals of the station.

Textile Veterans Association Honor Award. A bronze medallion is given to an outstanding graduating student in a textile course on the basis of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

In addition to the above, a number of other awards are available to AFROTC cadets only. Among them are the Thomas F. Costello Trophy, the Trustees' Medal, and the Alumni Medal.

OTHER ASSISTANCE FOR MASSACHUSETTS RESIDENTS ONLY

Board of Educational Assistance Scholarships

These scholarships for one-quarter, one-half, or full tuition are available both to freshmen and to upperclassmen. For full information write to

Executive Secretary
Board of Educational Assistance
200 Newbury Street
Boston 16, Mass.

Massachusetts Scholarship Foundation Scholarships

Awards ranging from \$200 to \$800 are made for the freshman year only by the Massachusetts Scholarship Foundation. For further information address

Massachusetts Scholarship Foundation
Committee on Awards
1746 Cambridge Street
Cambridge 38, Mass.

Higher Education Loan Plan

Under this HELP plan, students beyond the freshman year may obtain bank loans up to \$500 a year upon especially favorable terms. More specific information is available from

Massachusetts Higher Education
Assistance Corporation
1137 Statler Building
Boston 16, Mass.

PLACEMENT

Industrial Training Program

The Placement Office with the assistance of industry endeavors to place qualified underclassmen during summer vacation periods in industries of particular interest to the individual. These training opportunities are open to all students who have completed their sophomore year, except those on scholastic or disciplinary probation.

Objectives of the undergraduate Industrial Training Program are to supply essential industrial experience to the undergraduate, to provide the experience in human engineering only obtained in industry, to enable industry to preview individual students, and to further the liaison between the Institute and industry.

Placement Service

The Placement Office maintains active contacts with many industrial firms throughout the country in each of the fields of concentration presented at the Institute. A complete file of opportunities and data on the various industries and companies is available in the Placement Office to members of the graduating class.

The office arranges for representatives from industrial firms to interview students on campus. In a series of seminars speakers outline the opportunities in particular industries and various positions within the companies.

The office also aids industry in the difficult task of locating experienced personnel and assists alumni to establish new connections. The Placement Office cannot give any graduate a guarantee of employment; however, practically all seniors are placed prior to Commencement every year. No official part-time placement program is in operation because of the heavy academic schedule.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Memorial Library, the Research Foundation, and the Summer School program, the college provides such special services to industry and to the community as the following:

- Industrial seminars and conferences;
- Guidance work in the high schools;

Technorama, science fair for area high schools;

Consultive opportunities with the faculty;

Collaboration with the Agency for International Development of the government in its foreign aid program;

Special radio and television programs, such as Science Count-Down on Boston station WBZ-TV.

For information relative to these programs, address the Coordinator of Special Services at the Institute.

SUMMER SESSION

The Summer Session is designed primarily to serve three principal areas of interest: Professional Advancement Courses for industrial personnel; Undergraduate Credit Courses for college students with course deficiencies; and Precollege Refresher Courses for incoming freshmen at L.T.I.

The industry-sponsored professional advancement program comprises a series of specialized, intensive, one- to three-week courses in textiles, paper, leather, and other areas. The six-week undergraduate credit program stresses fundamental courses in college mathematics, physics, chemistry, English, economics, and foreign languages.

Precollege Refresher Courses

The Precollege Refresher Program is especially designed to articulate the high-school training of prospective L.T.I. students with the more intensive college-level studies in basic mathematics, physics, chemistry, and English. The noncredit refresher courses are offered both in a six-week and a four-week session in order to provide adequate coverage for a number of minor deficiencies in the high-school background.

For further information on the Summer Session, write to the Director of Summer School.

DIVISION OF EVENING STUDIES

The Division of Evening Studies offers five-year associate degree courses in chemistry, leather chemistry, paper chemistry, plastics chemistry, and rubber chemistry and in the following technologies: electrical engineering, electronic engineering, industrial engineering, and mechanical engineering. It also offers a program of individual subjects in mathematics, science, technology, engineering, and general studies. These subjects are designed to fit the needs of the community, particularly of those people engaged in industry who wish to further their education.

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. For further information, write to the Director of the Evening School.

In cooperation with the Massachusetts Division of Personnel and Standardization, the Division of Evening Studies also offers an In-Service Training Program in Civil Engineering Technology limited to employees of the Commonwealth of Massachusetts.



Research Foundation Laboratory

RESEARCH FOUNDATION

The Lowell Technological Institute Research Foundation is a nonprofit organization authorized under the laws of the Commonwealth of Massachusetts. It was established for the purpose of encouraging and administering research sponsored by industry and government at the Lowell Technological Institute.

Its research projects benefit the educational program of the Institute by enabling both faculty and students to keep abreast of current developments in their respective fields and to develop further their capabilities.

The scientists and engineers of the Foundation's permanent personnel, together with the faculty of the Institute, constitute a staff available for research, development, and testing in the fields of chemistry, electronics, engineering, leather, management, paper, plastics, and physics.

The Research Foundation has its own specialized laboratories and field stations where research ranging from chemical modification of textile fibers to studies of the ionosphere and thermal radiation is performed. The Foundation also uses in its programs the entire facilities of the Institute. These facilities not only include the usual research tools found in a university or industrial laboratory but also include, in the areas of leather, paper, plastics, and textiles, full-scale and pilot-plant equipment for specialized studies. It is probably the only research organization in the world having at its disposal fully equipped laboratories for processing all types of fibers by all the common manufacturing systems into a finished fabric.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, publishes the official alumni bulletin and the alumni directory, aids student organizations, and conducts its annual business meeting and reunion in the fall of each year. Those eligible for active membership include all students who have completed satisfactorily at least one year of the day curriculum, recipients of associate degrees from the Evening Division, and Evening Division senior-year candidates for associate degrees who apply to become members. Only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership Scroll and Citation may be awarded by the Board of Directors to any person who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to associate membership by the Board of Directors. The Honorary Award Scroll and Citation may be awarded by the Board of Directors to any active member of the Association who has made outstanding contribution to the arts or sciences.

Communications should be addressed to Professor A. Edwin Wells, Executive Secretary, Alumni Office, Lowell Technological Institute.

Officers

Joseph E. Weldon, '50, *President*

Gerald F. Quigley, '31, *First Vice President*

A. Chester Clifford, '22, *Second Vice President*

A. Edwin Wells, '20, *Clerk, Treasurer, and Executive Secretary*

J. Frederic Burtt, '31, *Assistant Secretary and Student Representative*

Charles J. Higgins, '54, *Executive Secretary of the Alumni Council*

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four officers elected by the student body, the president of each undergraduate class, and one representative from each of the classes. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee. In cooperation with the Text, the Council sponsors the annual Jacob K. Frederick Memorial Lecture Series.

Athletics

The Athletic Association promotes an extensive varsity and intramural sports program. Varsity sports are soccer, basketball, and baseball, and competition is mainly with college teams in the northeast section of the country. Golf and tennis teams also compete regularly with other colleges in the area. Intramural sports competition among classes, residence hall students, and fraternities is carried on throughout the year. All students are members of the Association and receive free admission to all inter-collegiate contests played at home.

Audio-Visual Society

Objectives of the Audio-Visual Society, composed of students and faculty members interested in this field, are to build and maintain a library of records, recorded tapes, and films, to record special events, and to present various types of audio-visual programs.

Auf Deutsch, Bitte

Informal German conversation marks all meetings of Auf Deutsch, Bitte whose purpose is to foster an understanding of the language, customs, and culture of the German people. Films, music, lectures, and personal anecdotes are featured, and coalition with German clubs of other universities is encouraged.

Band

The AFROTC Band includes cadets who are musicians or who wish to learn to play a band instrument. Besides providing music for AFROTC ceremonies, the band participates in various college and civic programs.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Circle K

This club is the student chapter of Kiwanis. Besides performing many services in the public interest, the members assist the administration in the annual freshman orientation program and provide tutorial help to freshmen.

Classics Club

Members conduct a series of book reviews, concerts, and informal lectures among themselves.

Dormitory Council

This Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a liaison between residents and the administration to maintain proper deportment and living conditions.

Drill Teams

Two AFROTC drill teams, armed and unarmed, are open to all cadets who desire to become proficient in precision drill. Exhibitions are presented at various functions throughout the academic year. The teams compete in the annual spring New York-New England College Drill Meet.

Duplicate Bridge League

Open to students and faculty members, the league conducts ten or more playing sessions each year to determine the champion team. Student members also participate in the annual national Intercollegiate Duplicate Bridge Tournament.

Fraternities

Four fraternities—Delta Kappa Phi, Omicron Pi, Phi Psi, and Pi Lambda Phi—have their own houses to provide centers for social life off campus. Three are national fraternity affiliates. The Interfraternity Council fosters the common interests of the four and sponsors interfraternity social and athletic events.

Indian Students' Association

Composed of students from India, this organization conducts social and cultural events throughout the year, several of them open to the public.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to adjust to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Nucleus

The Nucleus limits membership to 15 student leaders of all major activities on campus. High scholastic rating also is a requisite for active participation. The organization is primarily a discussion group.

Pershing Rifles

This national society is dedicated to the encouragement, preservation, and development of the highest ideals of the military profession. One of its activities is participation in several meets during the year as the AFROTC Armed Drill Team. Competition includes other AFROTC units as well as Army and Navy Pershing Rifles units.

Pickout

The Pickout is the college yearbook. Its staff is wholly responsible for the editorial, graphic, and business problems involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students and guest speakers present technical papers and lectures:

- American Association of Textile Chemists and Colorists, Student Chapter
- American Institute of Physics, Student Section
- American Society of Mechanical Engineers, Student Chapter
- American Society of Tool and Manufacturing Engineers, Student Chapter
- Chemistry Club
- Industrial Management Society
- Institute of Electrical and Electronics Engineers, Student Chapter
- Nuclear Society
- Paper Engineering Society
- Society of Plastics Engineers, Student Chapter
- Textile Society

Radio Station

WLTl is an all-student enterprise built and maintained by members of the LTI Broadcasting Society. Programs are transmitted by carrier current

from the studio to the various campus buildings. By selling air time to local merchants, the station is self-supporting. Its members learn business practices as well as broadcasting and other radio techniques.

Religious Groups

Hillel. The Hillel Counsellorship provides social, cultural, and religious programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship. Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Newman Club. The Newman Club conducts programs of a social and religious nature for Catholic students at the Institute and at Lowell State College.

Phanar Club. This is composed of Greek Orthodox students from Lowell State College and L.T.I.

Rifle Team

The AFROTC Rifle Team, chartered by the National Rifle Association, is open to all cadets. NRA-qualified members offer the instruction and training necessary for intercollegiate competition. Major matches of each year are the First U. S. Army Area Intercollegiate and Interscholastic Small-Bore Rifle Match and the Secretary of the Air Force Match.

Sorority

Phi Sigma Rho, the campus sorority, provides a center for the social life and association of the young women enrolled at the Institute.

Tau Epsilon Sigma

Membership in Tau Epsilon Sigma, the scholastic honor society at the Institute, is open to seniors and juniors who are elected on the basis of outstanding scholastic achievement and character.

Tech Alpine Club

Activities of the Alpine Club include mountaineering and hiking trips.

T.O.C.

The Tech Orientation Committee has as its special function the introduction of the new student to college life. T.O.C. plans a month-long series of activities for entering freshmen during the orientation period to enable them to meet one another and to realize their responsibilities to their college.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

The Text

The Text, the campus newspaper, is prepared and edited by students. The bi-weekly publication offers excellent journalistic and business experience to those who work on its staff.

Vandenberg Air Squadron of the Arnold Air Society

The Vandenberg Air Squadron, a chapter of the national Arnold Air Society, unites selected advanced AFROTC cadets by a fraternal bond to further the mission and traditions of the Air Force. The society provides social affairs and air space exhibits during the year. The Military Week End, annual highlight of its program, features a colorful drill ceremony and is climaxed by the formal Military Ball at which new members are accepted into the society.

Varsity Club

The Varsity Club is composed of students who have earned letters in the intercollegiate sports, baseball, basketball, golf, soccer, and tennis. Its purpose is to give academic help to athletes and to foster a lasting friendship among the men participating in athletics.

UNDERGRADUATE PROGRAMS

Eleven fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science. These fields are:

Chemical Engineering	Nuclear Science
Chemistry	Paper Engineering
Electrical Engineering	Physics
Industrial Management	Plastics Technology
Mechanical Engineering	Textile Engineering
Nuclear Engineering	

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

The Elective System

In all curricula an opportunity is afforded the student to elect subjects in addition to those required for graduation. These electives fall into two categories: technical electives and general electives.

Technical electives give the student a chance to broaden his professional knowledge by taking subjects allied to his main interest or to further his knowledge of a particular phase by taking additional work therein.

General electives are to be selected from the following subjects. At least two electives must be chosen in the social sciences (SS) and two in languages and literature (LL).

EC	201	Economics I	(3-0)3
EC	202	Economics II	(3-0)3
EC	301	Economic Development of the United States	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
LL	233	Comparative Literature	(3-0)3
LL	234	Shakespeare	(3-0)3
*LL	261-262	Elementary Technical German	(3-0) (3-0)6
*LL	263-264	Elementary Technical French	(3-0) (3-0)6
*LL	265-266	Elementary Technical Russian	(3-0) (3-0)6
*LL	361-362	Intermediate Technical German	(3-0) (3-0)6
*LL	365-366	Literary and Conversational Russian	(3-0) (3-0)6
LL	367-368	Literary and Conversational German	(3-0) (3-0)6
LL	467	Advanced Seminar in Literary German	(3-0)3
LL	468	Advanced Seminar in Literary German	(3-0)3
LL	471	The Modern American Novel	(3-0)3
LL	472	The Modern British Novel	(3-0)3
LL	473	World Drama	(3-0)3
LL	474	Modern Drama	(3-0)3
LL	482	The American Short Story	(3-0)3
SS	223-224	The United States Since 1865	(2-0) (2-0)4
SS	225	Europe: 1789-1914	(3-0)3
SS	226	Europe Since 1914	(3-0)3
SS	301	The Government of the United States I	(3-0)3
SS	302	The Government of the United States II	(3-0)3
SS	303	Psychology I	(3-0)3
SS	304	Psychology II	(3-0)3
SS	305 or 306	Sociology	(3-0)3
SS	371 or 372	American Civilization to 1865	(3-0)3
SS	459 or 460	International Relations	(3-0)3
SS	470	Comparative Modern Governments	(3-0)3
SS	471 or 472	Foreign Policy of the United States	(3-0)3

*These subjects are not accepted for credit, except as an overload, in Chemistry, Chemical Engineering, Electrical Engineering, Mechanical Engineering, Nuclear Engineering, and Textile Engineering.

SS	477 or 478	Twentieth-Century Russia	(3-0)3
SS	479 or 480	The Far East Since 1900	(3-0)3
SS	481 or 482	The Greeks and Western Civilization	(3-0)3
SS	483	Political and Social Thought from Ancient to Early Modern Times	(3-0)3
SS	484	Political and Social Thought from Early Modern Times to the Present	(3-0)3
SS	485 or 486	The Romans and Western Civilization	(3-0)3

The Air Force ROTC Program

By vote of the Board of Trustees, all able-bodied nonveteran male citizens enrolled at the Institute must satisfactorily complete two years of Air Force Reserve Officers Training courses (freshman and sophomore years) before receiving a Bachelor of Science degree.

Cadets who satisfactorily complete the Basic Course (the first two years) may apply for the Advanced Course (the last two years), subject to the approval of the Professor of Air Science.

Uniforms and all equipment and textbooks required for ROTC work are supplied by the United States Air Force. Students in the advanced course receive the standard cash payment allowed by the Air Force in lieu of subsistence.

Students who successfully complete the Advanced Course are commissioned as second lieutenants in the United States Air Force Reserve. Those who qualify receive further training after commissioning in scientific skills, pilot or navigator training, meteorology, and administration. Outstanding seniors who are designated Distinguished Military Graduates may compete for regular commissions and postgraduate education assignments.

BASIC COURSE

Freshman Year	First Semester	—AS	101	Foundations of Aerospace Power I (0-2)0
	Second Semester	—AS	102	Foundations of Aerospace Power II (2-2)2
Sophomore Year	First Semester	—AS	201	Fundamentals of Aerospace Weapon System I (2-2)2
	Second Semester	—AS	202	Fundamentals of Aerospace Weapon Systems II (0-2)0

ADVANCED COURSE

Junior Year	First Semester	—AS	301	The Growth and Development of Aerospace Power I (3-2)*
	Second Semester	—AS	302	The Growth and Development of Aerospace Power II (3-2)*

*New subject—credit hours not determined at time of publication.

Senior Year	First Semester	—AS	401	Global Relations I (2-2)1
		SS	403	Foundations of National Power (3-0)3
	Second Semester	—AS	402	Global Relations II (1-2)½
		SS	460	International Relations (3-0)3

A description of these subjects may be found in the section beginning on page 86.

Subjects required in the AFROTC program in the junior and senior years may be substituted for General Electives in all curricula unless otherwise specified.

Summer Camp

Each cadet enrolled in the Advanced Course is required to supplement his training by attending a summer camp of approximately four weeks duration, usually during the summer preceding his senior year. This encampment is held at one of several combat operational air bases where cadets have the opportunity to observe, fly, and live with career personnel. Transportation from the legal residence of the cadet to the camp and return, uniforms, food, lodging, and medical and dental care are provided by the Air Force, and in addition the cadet receives the pay of a basic airman.

Field Trips

Periodically, the Department of Air Science conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

Flight Instruction

The flight instruction program, designed for seniors in the Advanced Course who plan to enter Air Force pilot training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio, and weather. The flying phase consists of 36.5 hours of flight instruction at government expense.

Veterans

Any veteran who qualifies for and completes successfully the Advanced Course is commissioned a second lieutenant in the Air Force Reserve. Under present Air Force regulations, there is no requirement for an active duty tour; however, a veteran AFROTC graduate may apply for active duty as an officer. The Professor of Air Science may waive, in consideration of military service, portions of the basic course which cannot be completed prior to entrance into the advanced course.

Contribution to Student Life

Besides the military and academic phases of its program, the Department of Air Science sponsors various extracurricular activities which are designed to produce a well-rounded cadet. These include the Arnold Air Society, the Rifle Team, the Drill Teams, and the Band.

Cadet Decorations and Awards

A number of medals are awarded to selected cadets and cadet officers at a special parade and review held each spring. These include the Thomas F. Costello Trophy, the Alumni Medal, the Convair Cadet Award, the *Chicago Tribune* Awards, the Armed Forces Communications and Electronics Association Award, the Sons of the American Revolution ROTC Award, the Trustees' Medal, the Reserve Officer Association Medal, the Air Force Association Medal, the *Air Force Times* Award, and the Vandenberg Cup.

In addition, the Department of Air Science confers several medals and awards for outstanding performance in various fields, among them the Distinguished Military Cadet Awards.

Distinguished Military Graduate Awards are given to outstanding graduates, based on four years of over-all academic and military achievement. A recipient of this award may apply for a regular commission as second lieutenant in the United States Air Force.

The Freshman Program

ORIENTATION

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating the adjustment of the new student to his physical, social, and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Industrial Management* take the following subjects:

First Semester

†AS	101	Foundations of Aerospace Power I	(0-2)0
CH	101	General Chemistry	(4-2)4
LL	111	English I	(3-0)3
MA	107	Calculus and Analytic Geometry	(4-0)4
ME	101	Engineering Graphics	(1-2)1
PH	103	Physics	(4-1)4
			<hr/>
Total hours			(16-7)16

Second Semester

†AS	102	Foundations of Aerospace Power II	(2-2)2
CH	102	General Chemistry	(4-2)4
LL	112	English II	(3-0)3
MA	108	Calculus and Analytic Geometry	(5-0)5
ME	102	Engineering Graphics	(1-2)1
PH	104	Physics	(4-2)4
			<hr/>
Total hours			(19-8)19

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. Students taking Air Science are excused from one hour per week. No academic credit is given for the physical education program.

*See the Industrial Management curriculum on page 65.

†Required of all able-bodied, nonveteran male citizens. See page 55.

‡Required of all able-bodied, nonveteran male citizens. Other students must take in its place SS 102, Foundations of National Power (2-0)2.

Chemical Engineering

The Chemical Engineering curriculum is based on a thorough foundation in chemistry, physics, and mathematics upon which are built the fundamentals of chemical engineering: material and energy balances, thermodynamics, and unit operations. An effort is made to integrate the supporting basic sciences into the formal engineering courses. Emphasis is placed on the use of written and oral reports to clarify thinking and to promote the ability to communicate. The program is designed to train graduates not only to solve typical problems in the chemical engineering area but also to meet new and unfamiliar situations with competence.

A graduate of this program may elect to continue his studies in graduate school or to enter the industrial world directly. Opportunities exist in all major industrial areas, and the graduate chemical engineer can expect to find employment in old, new, and as yet unborn industries. The broad area in which chemical engineers are employed ranges from production and sales to research and teaching; thus, one is generally able to pursue a career which is challenging and personally satisfying.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
CH	201	Organic Chemistry	(3-3)4
CHE	201	Introduction to Chemical Engineering	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
Total hours			(16-7)17
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
CHE	204	Industrial Stoichiometry	(3-0)3
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(4-2)4
Total hours			(16-13)19

JUNIOR YEAR

First Semester

CH 331	Physical Chemistry	(3-3)4
CHE 303	Chemical Engineering	(3-0)3
EC 201	Economics I	(3-0)3
*LL 213	Introduction to English Literature	(3-0)3
ME 341	Thermodynamics	(3-0)3
	General Elective	(3-0)3
		Total hours (18-3)19

*ROTC students will substitute AS 301.

Second Semester

CH 332	Physical Chemistry	(3-3)4
CHE 304	Chemical Engineering	(3-0)3
CHE 312	Chemical Engineering Thermodynamics	(3-0)3
EC 202	Economics II	(3-0)3
*LL 214	Introduction to American Literature	(3-0)3
ME 382	Fluid Mechanics	(3-0)3
		Total hours (18-3)19

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

CHE 407	Industrial Chemistry	(3-0)3
CHE 411	Chemical Engineering Laboratory	(0-6)2
ME 261	Machine Tool Laboratory	(1-2)1
ME 313	Mechanics of Solids I	(3-0)3
ME 443	Heat Transfer	(3-0)3
	General Elective	(3-0)3
	Technical Elective	(3-0)3
		Total hours (16-8)18

Second Semester

CH 334	Colloid Chemistry	(3-0)3
CHE 410	Plant Design	(3-0)3
CHE 412	Chemical Engineering Laboratory	(0-6)2
ME 378	Mechanics of Solids II	(3-0)3
	General Elective	(3-0)3
	Technical Elective	(3-0)3
		Total hours (15-6)17

Chemistry

The curriculum in Chemistry is designed to provide both a thorough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. It includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The curriculum includes a minimum of eighteen credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist.

A graduate of the Chemistry curriculum may select any of several avenues in developing his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the Committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

Admission to the sophomore year in the curriculum is contingent upon the student's receiving a minimum average grade of C— in the two semesters of General Chemistry (CH 101-102) in his freshman year.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4

Total hours (16-13)19

*Alternate:	SS	223, The United States Since 1865	(2-0)2
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Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
CH	202	Organic Chemistry	(3-3)4
CH	206	Qualitative Analysis	(3-6)5
MA	206	Differential Equations	
	or		(3-0)3
MA	384	Statistical Methods	
PH	206	Physics	(4-2)4
		General Elective	(3-0)3

Total hours (16-13)19

JUNIOR YEAR

First Semester

CH	321	Organic Chemistry Laboratory II	(0-6)2
CH	331	Physical Chemistry	(3-3)4
EC	201	Economics I	(3-0)3
LL	261	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
			<hr/>
Total credit hours			18

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	342	Organic Qualitative Analysis	(1-6)3
EC	202	Economics II	(3-0)3
LL	262	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
			<hr/>
Total credit hours			19

SENIOR YEAR

First Semester

CH	411	Advanced Quantitative Analysis	(2-4)3
CH	443	Advanced Inorganic Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Two Technical Electives	6
			<hr/>
Total credit hours			18

Second Semester

CH	444	Advanced Inorganic Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Two Technical Electives	6
			<hr/>
Total credit hours			15

Seniors are strongly advised to take CH 423-424 (Advanced Organic Chemistry) or CH 431-432 (Advanced Physical Chemistry) as one of the technical electives. Other technical electives include CH 403-404, CH 408-409, and CH 481.

Electrical Engineering

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering with emphasis in electronics.

Students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classroom.

This curriculum is accredited by the Engineers' Council for Professional Development.

The criteria used for determining which students from the freshman class seeking to major in electrical engineering are acceptable as sophomores are as follows:

1. A cumulative rating of 2.1 for the second semester of the freshman year
2. No unremoved failures in freshman subjects
3. A grade of C (not C —) or higher in MA 108 and PH 104

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	201	Economics I	(3-0)3
EE	201	Fundamentals of Electrical Engineering	(3-0)3
EE	205	Basic Electrical Engineering Laboratory	(0-3)1
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	215	Engineering Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total hours			(19-7)20
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	202	Economics II	(3-0)3
EE	202	Fundamentals of Electrical Engineering	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	216	Engineering Mechanics II	(3-0)3
ME	264	Metals Processing	(1-2)1
		General Elective	(3-0)3
Total hours			(16-4)16

JUNIOR YEAR

First Semester

EE	301	Electronics	(3-0)3
EE	303	Electromagnetics	(3-0)3
EE	307	Network Analysis	(3-0)3
EE	309	Electronics Laboratory	(0-3)1
*LL	213	Introduction to English Literature	(3-0)3
MA	311	Engineering Mathematics	(3-0)3
Total hours			(15-3)16

*ROTC students will substitute AS 301.

Second Semester

EE	302	Electronics	(3-0)3
EE	304	Electromagnetics	(3-0)3
EE	308	Network Analysis	(3-0)3
EE	310	Electronics Laboratory	(0-3)1
*LL	214	Introduction to American Literature	(3-0)3
MA	312	Engineering Mathematics	(3-0)3
Total hours			(15-3)16

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

EE	401	Feedback Control Systems and Their Components	(3-0)3
EE	425	Electronics	(3-0)3
EE	427	Transistor Electronics	(3-4)5
Electives to total at least 6 credit hours			6
Minimum total credit hours			17

Electives

AS	401	Global Relations I	(2-2)1
and			
SS	403	Foundations of National Power	(3-0)3
EE	403	Microwave Electronics	(3-0)3
EE	405	Communication Electronics	(3-0)3
EE	411	Logical Design of Digital Computers	(3-0)3
EE	429	Network Synthesis	(3-0)3

Second Semester

EE	402	Feedback Control Systems and Their Components	(3-0)3
EE	426	Electronics	(3-0)3
EE	428	Transistor Electronics	(3-4)5
Electives to total at least 6 credit hours			6
Minimum total credit hours			17

Electives

AS	402	Global Relations II	(1-2)½
and			
SS	460	International Relations	(3-0)3
EE	404	Microwave Electronics	(3-0)3
EE	406	Communication Electronics	(3-0)3
EE	412	Logical Design of Digital Computers	(3-0)3
EE	430	Network Synthesis	(3-0)3

Industrial Management

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide the student with a foundation in science and engineering, in the humanities, and in the social sciences. In addition, the various aspects of management—business organization, production, distribution, accounting, and finance—are studied. The student extends his knowledge of mathematics to include statistics. He is also introduced to the newer research methods, including operations research, linear programming, and game theory. A graduate of this program can expect to find employment as a specialist in accounting, procurement, administration, technical sales, or personnel management.

FRESHMAN YEAR

First Semester

*AS	101	Foundations of Aerospace Power I	(0-2)0
CH	101	General Chemistry	(4-2)4
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	107	Calculus and Analytic Geometry	(4-0)4
ME	101	Engineering Graphics	(1-2)1
Total hours			(15-6)15

Second Semester

†AS	102	Foundations of Aerospace Power II	(2-2)2
CH	102	General Chemistry	(4-2)4
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	108	Calculus and Analytic Geometry	(5-0)5
ME	102	Engineering Graphics	(1-2)1
Total hours			(18-6)18

*Required of all able-bodied, nonveteran male citizens. See page 55.

†Required of all able-bodied, nonveteran male citizens. Other students must take in its place SS 102, Foundations of National Power (2-0)2.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	211	Economic Statistics I	(3-0)3
IM	241	Accounting I	(2-3)3
IM	321	Industrial Marketing I	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
ME	263	Metals Processing	(1-2)1
PH	103	Physics	(4-1)4
Total hours			(18-8)19

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	212	Economic Statistics II	(3-0)3
IM	242	Accounting II	(2-3)3
IM	322	Industrial Marketing II	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
PH	104	Physics	(4-2)4
Total hours			(15-7)16

JUNIOR YEAR

First Semester

IM	307	Corporation Finance	(3-0)3
ME	315	Applied Mechanics	(3-0)3
ME	343	Heat and Power	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
SS	303	Psychology I	(3-0)3

One of the Following Options[†]

AS	301	(A) The Growth and Development of Aerospace Power I	(3-2)*
IM	331	(B) Industrial Advertising	(3-0)3
IM	341	(C) Accounting III	(3-0)3
MA	205	(D) Calculus and Analytic Geometry	(4-0)4

Total credit hours 17 or 18

*New subject—credit hours not determined at time of publication.

[†]The specialization sequence selected by the student should be followed through the senior year.

Second Semester

EC	302	Labor Economics	(3-0)3
IM	308	Money and Banking	(3-0)3
IM	344	Cost Accounting	(2-2)3
IM	360	Business Law	(3-0)3
ME	372	Strength of Materials	(3-0)3

One of the Following

AS	302	(A) The Growth and Development of Aerospace Power II	(3-2)*
IM	334	(B) International Business Operations	(3-0)3
IM	342	(C) Accounting IV	(3-0)3
MA	206	(D) Differential Equations	(3-0)3
Total credit hours			18 or 19

*New subject—credit hours not determined at time of publication.

SENIOR YEAR

First Semester

EC	301	Economic Development of the United States	(3-0)3
EE	351	Industrial Electronics	(3-0)3
IM	411	Production Management I	(3-0)3
IM	461	Personnel Management	(3-0)3
SS	305	Sociology	(3-0)3

One of the Following

AS	401	(A) Global Relations I	(2-2)1
and			
SS	403	(A) Foundations of National Power	(3-0)3
IM	421	(B) Procurement	(3-0)3
IM	441	(C) Accounting V	(3-0)3
PH	205	(D) Physics	(4-2)4

Total credit hours 18 or 19

Second Semester

EC	402	Government and Business	(3-0)3
EC	412	Managerial Economics	(3-0)3
IM	412	Production Management II	(3-0)3
ME	494	Industrial Instrumentation	(2-0)2
		Special Major Elective*	(3-0)3

One of the Following

AS	402	(A) Global Relations II	(1-2) 1/2
and			
SS	460	(A) International Relations	(3-0)3
IM	444	(B) Sales Management	(3-0)3
IM	442	(C) Accounting VI	(3-0)3
PH	206	(D) Physics	(4-2)4

Total credit hours 17, 17 1/2, or 18

*EC 414, IM 470, IM 480, IM 484, IM 502, or IM 504. Other subjects by approval of adviser only.

Mechanical Engineering

This course trains the student in the application of the facts and methods of mathematics and science to the design and use of machinery and processes. Principles of design and analysis are stressed in all subjects, and the systems point of view is emphasized.

The student is thoroughly instructed in basic mathematics, physics, and chemistry. There is a unified sequence in applied mechanics which focuses on a course in design given in the senior year. The properties of engineering materials and the principles of thermodynamics, fluid mechanics, and heat transfer are taught, together with a series of subjects in electrical engineering.

In the laboratory the student becomes familiar with design techniques associated with typical energy conversion devices, controls, and instrumentation.

This curriculum is accredited by the Engineers' Council for Professional Development.

Requirements for admission to the sophomore year are a 2.0 cumulative average, no failures or incomplete courses, and a C average or better in freshman mathematics and physics.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total hours			(19-4)19
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	206	Physics	(4-2)4
Total hours			(16-5½)17

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	263	Metals Processing	(1-2)1
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	375	Materials Science	(3-2)3
		Two General Electives	(6-0)6
Total hours			(19-4)19

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
MA	356	Digital Computer Programming	(1-2)1
ME	314	Mechanical Engineering Laboratory I	(0-3)1
ME	318	Applied Mechanics IV	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
		General Elective	(3-0)3
Total hours			(16-7)18

SENIOR YEAR

First Semester

ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	443	Heat Transfer	(3-0)3
ME	495	Electromechanical Engineering	(3-2)4
		General Elective	(3-0)3
		Technical Elective	3
Total credit hours			17

Technical Electives

ME	431	Power Plant Systems	(2-3)3
ME	455	Information Processing Systems	(2-2)3
ME	471	Experimental Stress Analysis	(2-2)3

Second Semester

EC	414	Engineering Economy	(3-0)3
ME	416	Mechanical Engineering Laboratory III	(0-3)1
ME	492	Engineering Systems	(2-0)2
ME	496	Electromechanical Engineering	(3-2)3
		General Elective	(3-0)3
		Two Technical Electives	6
Total credit hours			18

Technical Electives

ME	422	Machine Design	(2-3)3
ME	456	Information Processing Systems	(2-2)3
ME	472	Experimental Stress Analysis	(2-2)3
ME	476	Physical Metallurgy	(3-0)3
ME	528	Kinematic Mechanism Synthesis	(3-0)3

Nuclear Engineering

The Nuclear Engineering course was the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.0, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total hours			(19-4)19
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	206	Physics	(4-2)4
Total hours			(16-5½)17

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
NU	301	Nuclear Radiation and Radiological Safety	(3-0)3
PH	363	Introductory Nuclear Physics	(3-0)3
		General Elective	(3-0)3
Total hours			(18-0)18

Second Semester

MA	302	Advanced Calculus	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
ME	476	Physical Metallurgy	(3-0)3
PH	366	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3
Total hours			(18-0)18

SENIOR YEAR

First Semester

ME	443	Heat Transfer	(3-0)3
NU	401	Nuclear Engineering	(3-0)3
NU	405	Reactor Theory	(3-0)3
NU	493	Nuclear Laboratory	(1-6)3
PH	461	Nuclear Physics	(3-0)3
		General Elective	(3-0)3
Total hours			(16-6)18

Second Semester

CH	484	Nuclear Chemistry and Radiochemistry	(3-3)4
NU	402	Nuclear Engineering	(3-0)3
NU	406	Reactor Theory	(3-0)3
NU	452	Nuclear Instrumentation II	(3-0)3
NU	494	Nuclear Laboratory	(1-6)3
		General Elective	(3-0)3
Total hours			(16-9)19

Nuclear Science

The course in Nuclear Science was the first to be offered by a publicly supported institution in New England. The curriculum emphasizes those fundamental subjects in physics and mathematics necessary for a basic education in all sciences and thus prepares the graduate for advanced studies as well as for responsible positions in industry.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.0, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EE	203	Fundamentals of Electricity	(3-0)3
LL	261	Elementary Technical German	
	or		(3-0)3
LL	265	Elementary Technical Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
PH	211	Intermediate Mechanics I	(3-0)3
Total hours			(19-4)19
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EE	204	Introductory Electronics	(3-1½)4
LL	262	Elementary Technical German	
	or		(3-0)3
LL	266	Elementary Technical Russian	
MA	206	Differential Equations	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	206	Physics	(4-2)4
PH	258	Electrical Measurements	(2-3)3
Total hours			(16-10½)18

JUNIOR YEAR

First Semester

MA 301	Advanced Calculus	(3-0)3
PH 311	Intermediate Mechanics II	(3-0)3
PH 321	Intermediate Thermodynamics	(3-0)3
PH 343	Atomic Physics	(3-1)3
PH 353	Electromagnetic Theory	(3-0)3
	General Elective	(3-0)3
Total hours		(18-1)18

Second Semester

MA 302	Advanced Calculus	(3-0)3
PH 324	Introduction to Statistical Mechanics	(3-0)3
PH 348	Physical Optics	(3-0)3
PH 362	Intermediate Nuclear Physics	(3-0)3
	Two General Electives	(6-0)6
Total hours		(18-0)18

SENIOR YEAR

First Semester

MA 433	Matrix Algebra	(3-0)3
NU 301	Nuclear Radiation and Radiological Safety	(3-0)3
NU 493	Nuclear Laboratory	(1-6)3
PH 461	Nuclear Physics	(3-0)3
	Technical Elective	3 or 4
	General Elective	(3-0)3
Total credit hours		18 or 19

Technical Electives

MA 543	Partial Differential Equations I	(3-0)3
MA 573	Functions of a Complex Variable	(3-0)3
PH 411	Quantum Theory	(3-0)3
PH 471	Solid State Physics	(3-0)3
PH 511	Classical Mechanics	(3-0)3
PH 523	Low-Temperature Physics	(3-3)4

Second Semester

CH 484	Nuclear Chemistry and Radiochemistry	(3-3)4
MA 484	Probabilities	(3-0)3
NU 452	Nuclear Instrumentation II	(3-0)3
NU 494	Nuclear Laboratory	(1-6)3
	Two Electives	(6-0)6
Total hours		(16-9)19

Technical Electives

MA 526	Modern Algebra	(3-0)3
MA 546	Partial Differential Equations II	(3-0)3
PH 412	Quantum Theory	(3-0)3
PH 472	Solid State Physics	(3-0)3
PH 512	Classical Mechanics	(3-0)3

Paper Engineering

The Paper Engineering program includes thorough training in basic chemical engineering along with the application of chemical and engineering principles to the manufacture of pulp and paper and to paper converting. A graduate of this program can go on to further studies in graduate school or directly pursue a career in the papermaking, paper-converting, and allied industries.

The paper industry is large and is growing larger; it is fifth in the nation in terms of the value of its products. It is also a stable industry, has operated more steadily and profitably in depression periods than most industries, and ranks very high in the matter of good employee relations. It is an interesting, rewarding, and challenging industry, and the shortage of men technically and scientifically trained to accept this challenge is acute. In addition to employment within the industry itself, a shortage of men trained in paper engineering also exists among companies which supply the paper industry with machinery, control equipment, raw materials, chemicals, and various industrial services.

The interest of industry in Paper Engineering graduates is evidenced by the generous scholarships available to students enrolled in this program. Five scholarships, each amounting to \$2,000 over a four-year period, are awarded each year to qualified entering freshmen. For details, see the section under Financial Aid in this catalogue.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
CH	201	Organic Chemistry	(3-3)4
CHE	201	Introduction to Chemical Engineering	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PA	201	Introduction to Paper Engineering	(1-0)1
PH	205	Physics	(4-2)4
Total hours			<u>(17-7)18</u>

*Alternate: SS 223, The United States Since 1865

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
CHE	204	Industrial Stoichiometry	(3-0)3
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(4-2)4
Total hours			<u>(16-13)19</u>

JUNIOR YEAR

First Semester

CH 331	Physical Chemistry	(3-3)4
CHE 303	Chemical Engineering	(3-0)3
EC 201	Economics I	(3-0)3
*LL 213	Introduction to English Literature	(3-0)3
PA 301	Pulp Systems	(3-0)3
PA 303	Pulp Systems Laboratory	(2-6)4
		<hr/>
Total hours		(17-9)20

*ROTC students will substitute AS 301.

Second Semester

CH 332	Physical Chemistry	(3-3)4
CHE 304	Chemical Engineering	(3-0)3
*EC 202	Economics II	(3-0)3
ME 382	Fluid Mechanics	(3-0)3
PA 302	Paper Systems	(3-0)3
PA 304	Paper Systems Laboratory	(1-6)3
		<hr/>
Total hours		(16-9)19

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

CHE 411	Chemical Engineering Laboratory	(0-6)2
ME 313	Mechanics of Solids I	(3-0)3
ME 341	Thermodynamics	(3-0)3
ME 443	Heat Transfer	(3-0)3
PA 403	Converting Processes	(3-0)3
PA 405	Converting Processes Laboratory	(0-6)2
	General Elective	(3-0)3
		<hr/>
Total hours		(15-12)19

Second Semester

CH 334	Colloid Chemistry	(3-0)3
CHE 312	Chemical Engineering Thermodynamics	(3-0)3
CHE 412	Chemical Engineering Laboratory	(0-6)2
ME 378	Mechanics of Solids II	(3-0)3
PA 414	Paper Research Problems	(1-6)3
	General Elective	(3-0)3
		<hr/>
Total hours		(13-12)17

Physics

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.0, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EE	203	Fundamentals of Electricity	(3-0)3
LL	261	Elementary Technical German	
	or		(3-0)3
LL	265	Elementary Technical Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
PH	211	Intermediate Mechanics I	(3-0)3
Total hours			(19-4)19
*Alternate:	SS 223,	The United States Since 1865	(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EE	204	Introductory Electronics	(3-1½)4
LL	262	Elementary Technical German	
	or		(3-0)3
LL	266	Elementary Technical Russian	
MA	206	Differential Equations	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	206	Physics	(4-2)4
PH	258	Electrical Measurements	(2-3)3
Total hours			(16-10½)18

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
PH	311	Intermediate Mechanics II	(3-0)3
PH	321	Intermediate Thermodynamics	(3-0)3
PH	343	Atomic Physics	(3-1)3
PH	353	Electromagnetic Theory	(3-0)3
		General Elective	(3-0)3
Total hours			(18-1)18

Second Semester

MA	302	Advanced Calculus	(3-0)3
ME	314	Mechanical Engineering Laboratory I	(0-3)1
PH	324	Introduction to Statistical Mechanics	(3-0)3
PH	348	Physical Optics	(3-0)3
PH	362	Intermediate Nuclear Physics	(3-0)3
		Two General Electives	(6-0)6
			<hr/>
Total hours			(18-3)19

SENIOR YEAR

First Semester

MA	433	Matrix Algebra	(3-0)3
PH	411	Quantum Theory	(3-0)3
PH	461	Nuclear Physics	(3-0)3
PH	471	Solid State Physics	(3-0)3
PH	493	Advanced Laboratory	(1-3)2
		Elective	3
			<hr/>
Total credit hours			17

Second Semester

MA	484	Probabilities	(3-0)3
PH	412	Quantum Theory	(3-0)3
PH	472	Solid State Physics	(3-0)3
PH	494	Advanced Laboratory	(1-3)2
		General Elective	(3-0)3
		Technical Elective	3
			<hr/>
Total credit hours			17

SENIOR YEAR

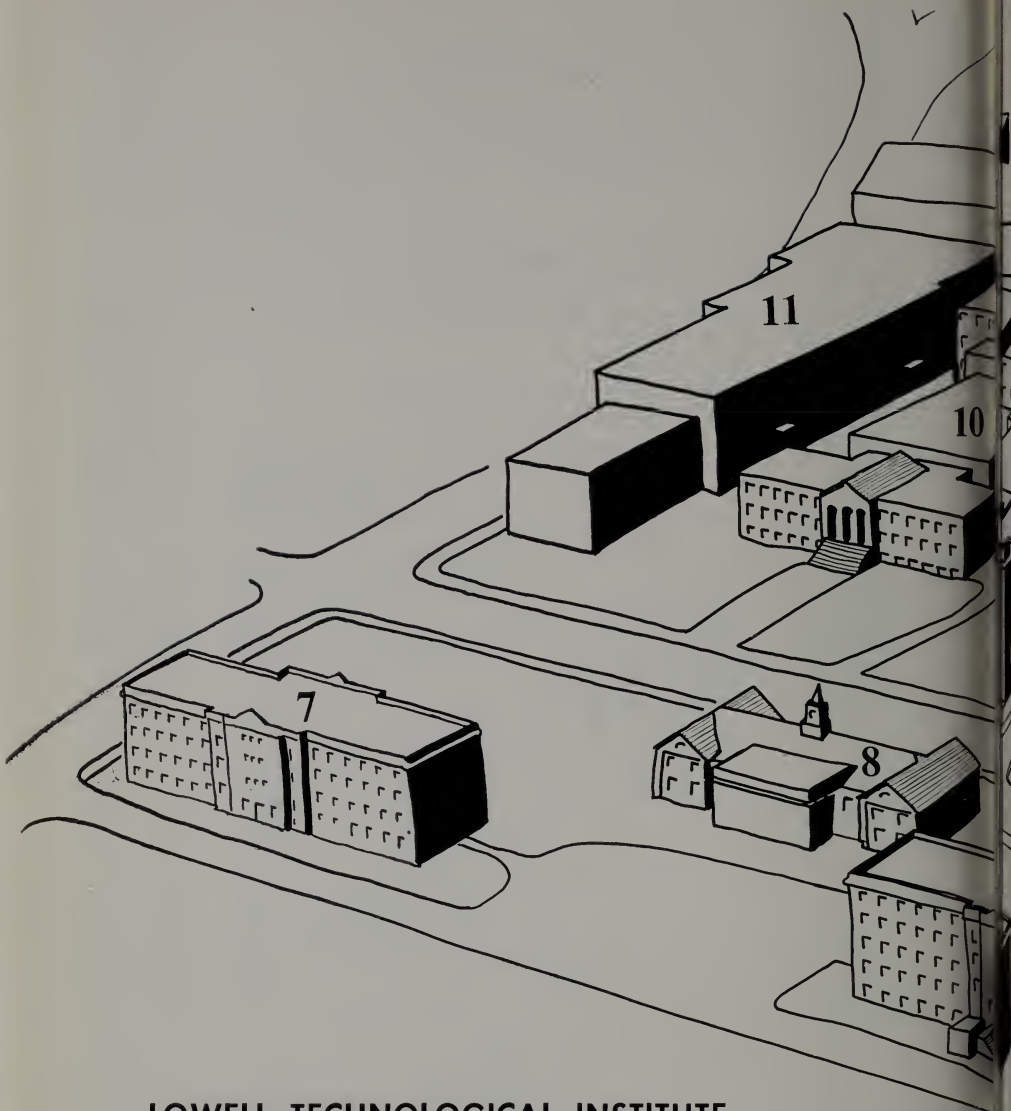
(Experimental Option)

First Semester

MA	459	Digital Computer Programming and Numerical Analysis	(2-3)3
PH	493	Advanced Laboratory	(1-3)2
		Experimental Elective	3
		Two Senior Electives (Theory)	6
		Technical or General Elective	3
			<hr/>
Total credit hours			17

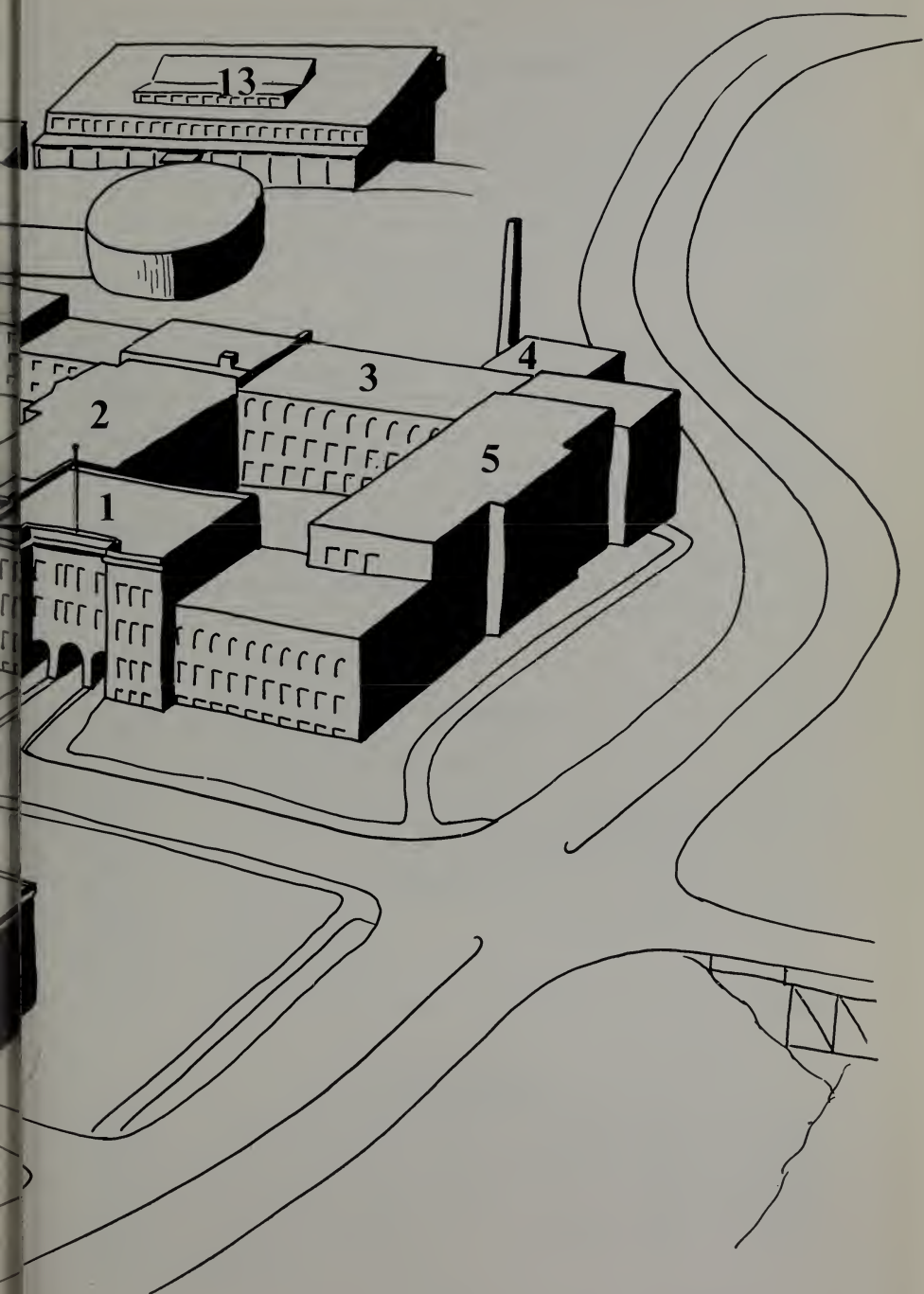
Second Semester

MA	460	Digital Computer Programming and Numerical Analysis	(2-3)3
PH	494	Advanced Laboratory	(1-3)2
		Experimental Elective	3
		General Elective	(3-0)3
		Two Senior Electives (Theory)	6
			<hr/>
Total credit hours			17



LOWELL TECHNOLOGICAL INSTITUTE LOWELL, MASSACHUSETTS

- | | |
|------------------------------|--|
| 1 — Southwick Hall | 8 — Alumni Memorial Library |
| 2 — Kitson Hall | 9 — Olney Hall |
| 3 — Falmouth Street Building | 10 — Cumnock Hall |
| 4 — Power Plant | 11 — New Classroom-Laboratory Building |
| 5 — Pasteur Hall | 12 — Nuclear Center (under construction) |
| 6 — Smith Hall | 13 — Proposed Gymnasium |
| 7 — Eames Hall | |



Plastics Technology

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials rather than on the chemical details involved in their synthesis.

However, the close relationship existing between the physical behavior and chemical structure of polymers makes it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics, and quality control augment the basic courses in mathematics, sciences, engineering, and plastics technology to round out a well balanced program.

Students electing Plastics Technology are privileged to become affiliated with the first student chapter of the International Society of Plastics Engineers, an opportunity which affords each student member an early and rewarding professional association.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
CH	201	Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
PL	201	Plastics Technology	(2-0)2
Total hours			(18-7)20
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
MA	384	Statistical Methods	(3-0)3
PH	206	Physics	(4-2)4
PL	202	Plastics Technology	(2-0)2
Total hours			(15-13)18

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
*EC	201	Economics I	(3-0)3
EE	355	Electronic Controls and Power Circuits	(3-2)4
ME	261	Machine Tool Laboratory	(1-2)1
ME	313	Mechanics of Solids I	(3-0)3
PL	301	Plastics Technology	(2-2)3
			Total hours (15-9)18

*ROTC students will substitute AS 301.

Second Semester

CH	332	Physical Chemistry	(3-3)4
*EC	202	Economics II	(3-0)3
ME	378	Mechanics of Solids II	(3-0)3
ME	374	Plastics Mold Design and Construction	(1-2)1
ME	376	Materials Science	(3-2)3
PL	302	Plastics Technology	(2-2)3
			Total hours (15-9)17

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4)4
ME	493	Industrial Instrumentation	(2-0)2
PL	401	Plastics Technology	(2-3)3
PL	403	Properties of Polymers	(2-3)3
PL	411	Plastics Seminar	(1-0)1
		Two Electives	(6-0)6
			Total hours (16-10)19

Second Semester

CH	404	Chemistry of High Polymers	(3-4)4
ME	382	Fluid Mechanics	(3-0)3
PL	402	Plastics Technology	(2-3)3
PL	404	Properties of Polymers	(2-3)3
PL	412	Plastics Seminar	(1-0)1
		Elective	(3-0)3
			Total hours (14-10)17

Suggested Electives

CH	406	Atomic and Molecular Structure	(3-0)3
CH	423-424	Advanced Organic Chemistry	(3-0) (3-0)6
IM	483 or 484	Statistical Quality Control	(3-0)3
LL	261-262	Elementary Technical German	(3-0) (3-0)6
MA	206	Differential Equations	(3-0)3
PL	406	Plastics Quality Procedures	(3-0)3

Textile Engineering

This course is based on a sound training in mathematics and science and their application to the solution of technical problems. The curriculum is similar to and related to that in Mechanical Engineering but includes sufficient subjects in textile science to qualify the student for positions in either production or research in the textile industry.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

*AS	201	Fundamentals of Aerospace Weapon Systems I	(2-2)2
EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total hours			(19-4)19
*Alternate:	SS 223, The United States Since 1865		(2-0)2

Second Semester

AS	202	Fundamentals of Aerospace Weapon Systems II	(0-2)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	206	Physics	(4-2)4
Total hours			(17-7½)18

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	375	Materials Science	(3-2)3
TE	361	Textile Systems I	(4-4)4
		General Elective	(3-0)3
Total hours			(19-6)19

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
MA	356	Digital Computer Programming	(1-2)1
ME	314	Mechanical Engineering Laboratory I	(0-3)1
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
TE	362	Textile Systems II	(4-2)4
		General Elective	(3-0)3
Total hours			(17-9)19

SENIOR YEAR

First Semester

ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	443	Heat Transfer	(3-0)3
ME	495	Electromechanical Engineering	(3-2)4
TE	471	Textile Evaluation	(2-3)3
TE	483	Engineering Design of Textile Structures	(3-0)3
		General Elective	(3-0)3
Total hours			(16-11)20

Second Semester

ME	416	Mechanical Engineering Laboratory III	(0-3)1
ME	492	Engineering Systems	(2-0)2
TE	482	Application of Scientific Methods to Textile Processes	(3-0)3
TE	484	Engineering Design of Textile Structures	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective	3
Total credit hours			18

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS	Air Science	ME	Mechanical Engineering
CH	Chemistry	NU	Nuclear Science and Engineering
CHE	Chemical Engineering	PA	Paper
EC	Economics	PH	Physics
EE	Electrical Engineering	PL	Plastics
IM	Industrial Management	SS	Social Sciences
LL	Languages and Literature	TC	Textile Chemistry
MA	Mathematics	TE	Textiles

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are restricted to graduate students. An asterisk following the subject number, e.g., PH 411-412*, indicates a subject which, although it is primarily for undergraduates, may ordinarily be taken for full graduate credit.

Odd numbers designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Hyphenated numbers indicate subjects continuing throughout the year.

Prerequisites are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.



AFROTC Drill Team Ceremony



Soccer Team

Air Science

AS 101-102 Foundations of Aerospace Power (0-2) (2-2)2 **I and II**

An introductory examination of the factors of aerospace power, major ideological conflicts, requirements for military forces in being, responsibilities of citizenship, development and traditions of the military profession, role and attributes of the professional officer in American democracy, organization of the armed forces as factors in the preservation of national security, and the United States Air Force as a major factor in the security of the free world.

AS 201-202 Fundamentals of Aerospace Weapon (2-2) (0-2)2 **Systems I and II**

An introductory survey of aerospace missiles and craft, and their propulsion and guidance systems; target intelligence and electronic warfare; nuclear, chemical, and biological warhead agents; defensive, strategic, and tactical operations; problems, mechanics, and military implications of space operations; and a survey of contemporary military thought.

AS 301-302 (OE 300) The Growth and (3-2) (3-2)* **Development of Aerospace Power I and II**

An advanced study of communication skills, the nature of war, the history of airpower, the United States Air Force, astronautics and space operations, and the future development of aerospace power. In addition to the three class hours per week cadets have one hour per week of supervised research in the Institute or detachment library preparing briefings and written reports assigned in class. Cadets also take one hour of leadership laboratory per week.

*New course—credit hours not determined at time of publication.

AS 401-402 Global Relations I and II (2-2) (1-2)1½

An intensive study of global relations of special concern to the Air Force officer, with emphasis on international relations and geography, briefing for commissioned service, weather and aerial navigation, and plans and programs staff development.

Chemistry

CH 101-102 General Chemistry (4-2) (4-2)8

Chemical principles and calculations. The chemistry of both metallic and nonmetallic elements and of their compounds and a brief survey of organic chemistry.

CH 201-202 Organic Chemistry (3-3) (3-3)8
[CH 102]

The classification, nomenclature, structure, mechanism of reaction, and behavior in bulk of important kinds of organic species. The laboratory work illustrates the experimental techniques which can be used to react, purify, characterize, and identify organic substances.

CH 203 Elementary Organic Chemistry (3-0)3
[CH 102]

This subject enables students not majoring in chemistry to become conversant with the names, structural formulas, properties, and uses of some important industrially available organic substances and with the role which organic chemistry plays in industry and engineering.

CH 205 Qualitative Analysis (3-0)3
[CH 102]

[Primarily for students not majoring in chemistry]

A lecture course dealing with the physical chemistry of aqueous electrolytic solutions. The nature and behavior of solutes and solutions; reaction rate theory and its relation to solubility, proton transfer, and other types of equilibria; and application of the above principles to problems of separation and identification.

CH 206 Qualitative Analysis (3-6)5
[CH 102]

[Primarily for students majoring in chemistry]

Lecture material essentially the same as in CH 205. The laboratory includes experiments illustrating physical-chemical principles as well as some techniques of qualitative analysis, including chromatography, ion exchange, microscopy, and chemical methods of separation.

CH 211 or 212 Quantitative Analysis (3-6)5
[CH 102]

The fundamental principles of quantitative analysis. The principles and calculations of gravimetric analysis, including an introduction to mineral separations as well as the analysis of soluble salts; the principles and calculations of volumetric analysis, including neutralization methods, oxidation-reduction methods, and iodometric methods. Offered both semesters.

CH 321 Organic Chemistry Laboratory II (0-6)2
[CH 202]

A continuation of the laboratory portion of CH 202 involving additional laboratory work in synthetic organic chemistry.

CH 331-332**Physical Chemistry**
[CH 102, MA 205, PH 205]**(3-3) (3-3)8**

The formulation and development of the mathematical and mechanical models of theoretical chemistry and their uses in the solution of the practical problems of chemistry and chemical engineering. Topics included are atomic and molecular structure, states of matter, thermodynamics, thermochemistry solutions, electrochemistry, colloids, chemical equilibrium, kinetics, and photochemistry.

CH 334**Colloid Chemistry**
[CH 331 or equivalent]**(3-0)3**

Theoretical properties of the colloid system. Interfacial phenomena, particle kinetics, electrical properties, and viscosity characteristics are studied. The character of lyophobic and lyophilic sols, gels, and emulsions is developed from the above properties.

CH 342**Organic Qualitative Analysis**
[CH 202; CH 205 or 206]**(1-6)3**

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 402***History of Chemistry Seminar****(1-0)1**

A seminar for seniors and graduate students in chemistry. The history of chemistry and the philosophy of science. Assigned readings discussed under the guidance of selected faculty members.

CH 403-404**Chemistry of High Polymers****(3-4) (3-4)8**

The physical and organic chemistry of monomers and polymers, including a consideration of non-bonding forces, spectroscopic methods of structure determination, structure and property correlations, fractionation, thermodynamics, and methods of molecular weight determination for polymers in solution; the kinetics of condensation and addition polymerization as applied to polymers and copolymers, mechanism of free radical and ionic polymerization, stereospecific polymers, the chemistry of the more common polymer systems, and preparation of their corresponding monomers.

CH 406***Atomic and Molecular Structure**
[CH 332]**(3-0)3**

Modern concepts of atomic and molecular structure are developed, and the theory is related to observed chemical phenomena.

CH 408-409**Advanced Studies in Chemistry****Credits to be
arranged**

[Permission of the Chairman of the Chemistry Division and the instructor]

Advanced work in analytical, organic, inorganic, physical, or textile chemistry, including literature survey, laboratory work, and reports.

CH 411 Advanced Quantitative Analysis (2-4)3
[CH 211 or 212; CH 332]

Advanced analytical techniques based on physical-chemical principles and utilizing instrumental methods wherever applicable. The analytical use of complexes, radiant energy methods, electrochemistry, chromatography, polarography, analytical applications of radioisotopes, and physical methods of separation.

CH 423-424* Advanced Organic Chemistry (3-0) (3-0)6
[CH 202]

Extension of first-year organic chemistry to include additional classes of compounds and special topics. Emphasis is placed on synthetic methods, including the mechanism, scope, and limitations of the important name reactions in the field of synthetic organic chemistry.

CH 431-432* Advanced Physical Chemistry (3-0) (3-0)6
[CH 332]

An extension of introductory physical chemistry for majors in chemistry and related fields, including additional work in chemical thermodynamics, kinetics, and equilibrium as they apply to the various chemical phenomena, with emphasis on the use of chemical literature, methods of treating data, and problem solving.

CH 443-444* Advanced Inorganic Chemistry (3-0) (3-0)6
[CH 332]

A treatment of the structure and reactions of the inorganic elements and their compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics and the theory of the chemical bond, spectroscopy, inorganic stereochemistry, crystal field theory, reactions in nonaqueous solvents, coordination chemistry, and atomic structure, including the structure of the atomic nucleus.

CH 481 Radiochemistry (3-3)4
[CH 332]

Fundamentals of radiochemistry, including radioactivity, atomic nuclei, nuclear reactions, reactors, and radiation detection and measurement with emphasis on the use of radioactive materials in chemical applications. Designed primarily for majors in chemistry and in allied fields.

CH 483 or 484 Nuclear Chemistry and Radiochemistry (3-3)4
[CH 102]

A review of chemical principles as applied to radiochemistry, including coverage of such topics as radioactivity, nuclear reactors, radiation chemistry, use of tracers in chemical applications, and separation and study of fission products.

CH 501 Absorption Spectrophotometry and Color (2-3)3
Measurement

Theory and application of absorption spectrophotometry to the qualitative and quantitative analyses of chemical substances in both transparent and opaque media in the ultraviolet, visible, and near infrared ranges, including theories of color, vision, and subjective color evaluation.

CH 503-504 Chemistry of High Polymers (3-0) (3-0)6
[CH 202, CH 332]

An introduction to the physical and organic chemistry of high polymers for graduate students. Similar to CH 403-404 but with additional assigned reading.

CH 505 Interpretation of Data (3-0)3

Mathematical methods of analyzing, plotting, and interpreting experimental data. Lectures and exercises.

CH 507-508 Chemistry Seminar (1-0) (1-0)2

CH 512 Physical Chemistry of Surface-active Agents (2-0)2

A series of lectures on the physicochemical principles involved in the use of surface-active agents. The surface and bulk properties of the agents are studied and related to the over-all technical properties and uses.

CH 513 Chemical Applications of Spectroscopy and (3-0)3
Spectrophotometry

Theory, limitations, and applications of various types of spectroscopy to chemical research. Visible and ultraviolet, infrared, microwave, nuclear magnetic, and electron paramagnetic resonance spectroscopy. Emphasis is given to the interpretation of spectra, with some importance placed on analytical applications.

CH 514 Physicochemical Methods (2-0)2

An outline of some of the more important physical methods of investigation and their applications to chemical research, including refractometry, polarimetry, microscopy, and chromatography (ion-exchange, adsorption, and gas).

CH 521-522 Physical Organic Chemistry (3-0) (3-0)6
[CH 424]

Modern concepts of molecular structure developed and related to the physical and chemical properties of organic compounds. Polarization effects and reaction mechanisms considered in detail.

CH 523 Physical Chemistry of Macromolecules (3-0)3
[CH 404, CH 432]

An advanced treatment of the physical chemistry of macromolecules, including methods available for molecular structure determination. Consideration of the thermodynamic and statistical approaches to the theory of high-polymer solutions, with particular emphasis on molecular weight dependencies and a study of the kinetics of polymerization and depolymerization.

Offered in alternate years; not offered in 1963-64.

CH 524 Organic Chemistry of Macromolecules (3-0)3
[CH 403, CH 424]

An advanced study in polymer science concerned with modern theoretical concepts and including mechanisms of formation and degradation of macromolecules.

Offered in alternate years; not offered in 1963-64.

CH 525 Chemistry of the Carbohydrates (3-0)3
[CH 332 or equivalent]

Starting with the chemistry of the simple sugars, this subject leads to a detailed study of the physical chemistry and the organic chemistry of the important polysaccharides, such as cellulose and starch, and of their industrially important derivatives.

CH 526 Polymer Physics (3-0)3

A general treatment of the physical behavior of high-polymer systems. Lectures cover microscopic structure, including the structure of polymer molecules, intermolecular forces, first- and second-order transitions and macroscopic behavior including rheology and mechanical behavior, the kinetic theory of rubber elasticity, electrical, optical, and thermal properties. Comparisons are made with other classes of materials from time to time to emphasize the unique properties of high polymers.

CH 527-528 Stereochemistry (2-0) (2-0)4

The fundamental concepts of optical and geometrical isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds.

Offered in alternate years; offered in 1963-64.

CH 531-532 Chemical Thermodynamics (3-0) (3-0)6
[CH 539-540 or equivalent]

An advanced subject in chemical thermodynamics, with emphasis on the recent mathematical developments in the description of chemical systems and with attention given to current experimental methods of obtaining thermodynamic data. The chemical and physical scientific literature is used extensively.

CH 533 Statistical Mechanics for Chemists (3-0)3
[CH 539-540 or equivalent]

A continuation of the introductory statistical mechanics presented in CH 539-540. Current theories on such topics as configuration of polymer molecules, rubber elasticity, and solution structure, as well as principles of classical statistical mechanics.

CH 534 Quantum Mechanics for Chemists (3-0)3
[CH 539-540 or equivalent]

A continuation of the introduction to quantum mechanics in CH 539-540. Current theories on such topics as quantum mechanical treatment of crystalline solids, imperfect gases and liquids, and electromagnetic susceptibilities.

CH 535-536 Advanced Topics in Physical Chemistry (3-0) (3-0)6

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 537 Chemical Kinetics (3-0)3

The theoretical and empirical treatment of chemical kinetic data of both organic and inorganic chemistry as well as the methods of obtaining these data. The determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanisms, complex reactions, and absolute rate theory.

CH 538 Rheology (2-0)2

The general principles of the deformation and flow of matter under stresses studied qualitatively and quantitatively. Hookean and non-Hookean elasticity and Newtonian and non-Newtonian flow related to the properties of materials, especially in the field of high polymers.

CH 539-540 Theoretical Chemistry (3-0) (3-0)6
[CH 431-432 or equivalent]

The formal aspects of quantum mechanics, thermodynamics, and statistical mechanics providing a conceptual and mathematical background for interpreting the behavior of chemical systems.

CH 541-542 Graduate Thesis Credits to be arranged

An independent investigation of a problem by the student in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

CH 561-562 Advanced Organic Synthesis (2-0) (2-0)4
[CH 423-424 or equivalent]

The application of known organic reactions to the synthesis of chemical species in such fields as the terpenes, steroids, alkaloids, antibiotics, and selected heterocyclic derivatives.

Offered in alternate years; not offered in 1963-64.

CH 564 Organic Qualitative Analysis (1-6)3

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565 Metal-Organic Compounds (3-0)3

The chemistry of the important classes of metal-organic compounds, including bis-arene derivatives, as well as the organo-silicon, organo-boron, and organo-phosphorus classes.

Offered in alternate years; offered in 1963-64.

CH 566 Heterocyclic Chemistry (3-0)3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years; offered in 1963-64.

Chemical Engineering

CHE 201 Introduction to Chemical Engineering (3-0)3
[CH 102]

Reaction rate, equilibrium, and related topics followed by an investigation of a segment of the chemical industry. Library research on selected topics, together with oral and written reports.

CHE 204 Industrial Stoichiometry (3-0)3
[CH 205 or CHE 201; CH 212 taken concurrently]

The application of material and energy balances, including phase separation and thermochemistry, in chemical engineering processes.

CHE 303-304 Chemical Engineering (3-0) (3-0)6
[CHE 204, MA 205; ME 382 taken concurrently]

The unit operations of size reduction, mixing, materials handling, filtration, mass transfer, gas absorption, distillation, air-water contact operations and drying, leaching and extraction, and crystallization and evaporation.

CHE 312 Chemical Engineering Thermodynamics (3-0)3
[ME 341]

Application of the first and second laws to chemical engineering problems. Heats of reaction and enthalpy changes as a function of temperature; fugacity and activity, state properties, homogeneous and heterogeneous equilibria, and electrochemical effects.

CHE 407 Industrial Chemistry (3-0)3
[CHE 204]

Important industrial chemical processes studied quantitatively. The processes are analyzed by means of material and energy balances together with equilibrium and kinetic considerations.

CHE 410 Plant Design (3-0)3
[CHE 304]

Economic principles applied in the evaluation and optimization of various chemical engineering processes. Several minor projects and a major design problem requiring written reports provide practical application of the various principles.

CHE 411-412 Chemical Engineering Laboratory (0-6) (0-6)4
[CHE 304]

Experimental studies of various unit operations performed as co-operative efforts by groups of students. Written and oral reports are required.

Economics

EC 201 Economics I (3-0)3

The foundations and nature of economic principles. National income, money and banking, and monetary and fiscal policy.

EC 202 Economics II (3-0)3
[EC 201]

Price and production theories, the distribution of income, comparative economic systems, and a brief survey of economic doctrines.

EC 211-212 Economic Statistics I and II (3-0) (3-0)6

Basic concepts of statistical methods with special emphasis on those approaches of most interest to students of management. Topics covered include measures of central tendency, dispersion, frequency distributions, probability distributions, tests of hypotheses, regression analysis, multiple and partial correlation, time series, seasonal variations, index numbers, and analysis of variance.

EC 301 Economic Development of the United States (3-0)3

The background of the present economic system and an intensive study of the influence of science and technology upon our economic development.

EC 302 Labor Economics (3-0)3
[EC 202]

The effect of the operation of American capitalism upon the position of labor. Analysis of the rise of union organization and the factors in its growth. Consideration of trends in the labor forces, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 Intermediate Microeconomic Theory (3-0)3
[EC 202]

An advanced examination of price and production theory. The theory of the household and the firm.

EC 304 Intermediate Macroeconomic Theory (3-0)3
[EC 202]

An analysis of Keynesian and post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 401 International Trade Theory (3-0)3
[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 402 Government and Business (3-0)3
[EC 202]

An examination of federal, local, and state controls on business activity, with emphasis on the economic interpretation of the various statutes and court decisions involving business.

EC 412 Managerial Economics (3-0)3
[EC 202]

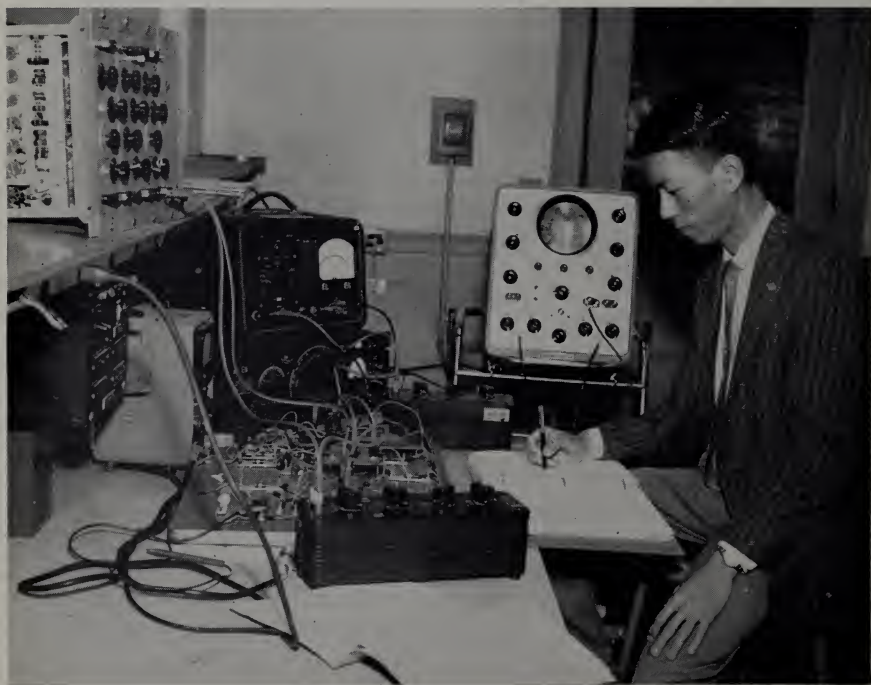
An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis, and competitive action.

EC 414 Engineering Economy (3-0)3
[EC 202, IM 242; or permission of instructor]

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.



Chemistry Laboratory



Electrical Engineering Laboratory

Electrical Engineering

EE 201-202 Fundamentals of Electrical Engineering (3-0) (3-0)6 [MA 108 and PH 104; MA 205 and 206 taken concurrently]

An introduction to the study of the mathematical and physical aspects of electric circuits in which radiation in the form of electromagnetic waves does not play a major role. Kirchhoff's laws, Thevenin's theorem, reciprocity of simple circuits, vector diagrams, vector algebra, sinusoidal steady-state behavior of simple circuits, transients in alternating-current circuits, coupled circuits and transformers, polyphase systems, and an introductory discussion of simple nonlinear circuits.

EE 203 Fundamentals of Electricity (3-0)3 [PH 104; MA 205 taken concurrently]

An introduction to electric circuits for students not majoring in Electrical Engineering but who have a background in basic principles of electricity and magnetism. Direct-current circuits, network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state a.c. circuits, two-terminal networks, and two-terminal-pair networks.

EE 204 Introductory Electronics (3-1½)4 [EE 203, MA 205]

A background subject in electronics for students not majoring in Electrical Engineering, presenting the properties and uses of vacuum tube and semiconductor devices.

EE 205 Basic Electrical Engineering Laboratory (0-3)1 [EE 201 taken concurrently]

Experimental work designed to acquaint the student with electrical instruments and the techniques of electrical measurements and to provide experimental verification of the behavior of passive electrical circuits.

EE 301-302 Electronics (3-0) (3-0)6 [EE 201-202, MA 205 and 206]

Principles and methods of analysis of electronic devices, models, circuit function, and systems; the use of piecewise-linear circuit models; transistor and electronic tube models and circuits; wave shaping and amplification; rectification and detection; wave-form generation; oscillations in RLC circuits; and symmetry and balanced circuits.

EE 303-304 **Electromagnetics** **(3-0) (3-0)6**
[EE 202, MA 206]

Electricity and magnetism presented from the field theory point of view, using vector analysis and Maxwell's equations. The static electric field in polarizable and conducting media, static magnetic fields of steady electric currents and ferromagnetic materials, time-changing electric and magnetic fields, magnetic induction, electromagnetic waves and energy flow, and boundary value problems.

EE 307-308 **Network Analysis** **(3-0) (3-0)6**
[EE 202, MA 206]

Continuation of discussions begun in EE 201-202, with emphasis on frequency domain analysis. Mutual inductance, coupled circuits, and transformers; open-circuit and short-circuit natural frequencies and impedance by inspection techniques; complete solution of linear passive networks; power and energy associated with arbitrary excitation functions; Fourier and Laplace transformations and a comparison of network analysis by these methods with the classical differential equation approach; numerical evaluation methods using impulse train techniques; and convolution in the time and frequency domain. Selected topics from the theory of determinants, matrices, linear transformations and quadratic forms and functions of a complex variable emphasizing the basic aspects for analysis problems. A brief introduction to synthesis.

EE 309-310 **Electronics Laboratory** **(0-3) (0-3)2**
[EE 301-302 and EE 307-308 taken concurrently]

Basic electronic circuits and the techniques of measurement for evaluating their performance, with particular emphasis on experimental investigation of pertinent topics discussed analytically in EE 301-302 and EE 307-308.

EE 324 **Electrical Energy Conversion** **(3-2)4**
[EE 203, MA 205]

An introductory subject for non-Electrical Engineering students, presenting the generation, control, utilization, and conversion of electrical energy, with special attention given to the construction, characteristics, and operation of direct-current and alternating-current machinery, selsyns, and rectifiers.

EE 351 or 352 **Industrial Electronics** **(3-0)3**
[MA 108, PH 104]

Not open to students majoring in Electrical Engineering, Mechanical Engineering, Physics, or Textile Engineering.

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum and gaseous tube characteristics and of circuits containing such tubes for the purpose of rectification, amplification, and oscillation; and industrial photoelectric relays, time delay relays, and Thymotrol motor controls.

EE 355 Electronic Controls and Power Circuits (3-2)4

Power requirements in single-phase and three-phase power circuits; operating characteristics of various types of direct-current and alternating-current motors and their manual and automatic controls; and industrial electronics including photoelectric relays, time delay relays, and motor control.

**EE 401-402 Feedback Control Systems and (3-0) (3-0)6
 Their Components**

[EE 302, EE 308, MA 312]

The various methods of analysis and design of control systems, including the time-domain, frequency-domain, and root-locus approaches, and a broad coverage of control system components. Laboratory demonstrations are included in the second semester.

EE 403-404 Microwave Electronics (3-0) (3-0)6

[EE 304, MA 312]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, generation and focusing of high-current electron beams with electric and magnetic fields, electron optics, velocity modulation, space charge wave propagation and traveling wave interaction with electron beams with application to microwave amplifiers and oscillators, and antennas.

EE 405-406 Communication Electronics (3-0) (3-0)6

[EE 302, MA 312]

Theory and application of thermionic tubes and transistors in amplifiers, oscillators, modulators, and detectors operating class A and in the switching mode. Principles of television communication.

EE 411-412 Logical Design of Digital Computers (3-0) (3-0)6

[EE 302]

Foundations for the complete design of digital computer subsystems, such as arithmetic unit, computer memory, control, and input-output equipment with emphasis on basic circuitry as well as the logical tools: flip-flops, shift-register, logical gates, and magnetic core memories. Boolean algebra, systems synthesis, coding, and error detection.

EE 425-426 Electronics (3-0) (3-0)6

[EE 302, EE 308, MA 312]

A unified approach to the piecewise-linear analysis of vacuum tube and solid-state devices used in pulse and digital applications, with emphasis on the basic modes of operation derived through the break-point and assumed-diode-state techniques. Topics include linear wave shaping, waveform generation, timing, switching negative-resistance devices, and oscillations.

EE 427-428 Transistor Electronics (3-4) (3-4)10
[EE 302, EE 308, MA 312]

Properties of semiconductor devices; a study of transistors as active network elements, based on two-part theory in matrix presentation; transistor devices analyzed in the periodic steady state and the transient state by transform methods and other methods; and solution by modern methods of problems on linear and nonlinear semiconductor devices. Practical experience in transistors, tunnel diodes, and similar devices is gained from an extensive laboratory course.

EE 429-430 Network Synthesis (3-0) (3-0)6
[EE 308, MA 312]

A review of methods of analysis useful in the study of signals, systems, and their response; impedance and admittance properties relating the frequency and time domain aspects of physical circuit behavior; linear passive network theory, emphasizing the synthesis aspects; fundamental works of Foster, Cauer, Brune, Darlington, and Guillemin applied to design of networks having a prescribed driving-point and transfer characteristics; synthesis of coupling networks for prescribed transfer characteristics, including RC, RLC, and minimum-phase and nonminimum-phase types; real part sufficiency and related topics; and Fourier, Laplace, and Hilbert transforms.

EE 431-432 Special Topics in Electronics (3-0) (3-0)6

An analytical consideration of special topics of importance in the field of electronics.

EE 501-502 Applied Statistics (3-0) (3-0)6

Consideration of electromagnetic waves in physical media by statistical analysis methods.

EE 503-504 Solid-State Physical Electronics (3-0) (3-0)6

A physical interpretation of the properties of materials in terms of their dielectric constant, magnetic permeability, and electrical conductivity; dielectric, ferroelectric, and piezoelectric materials; diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic materials; metals, semiconductors, and insulators; and applications to electrical engineering devices.

EE 505-506 Microwave Electronics (3-0) (3-0)6

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers, klystrons, magnetrons, and traveling wave tubes.

EE 509-510 Transients in Electromechanical Systems (3-0) (3-0)6

Training in the formulation and solution of ordinary and partial differential equations which arise in the treatment of mechanical, acoustical, thermal, and electrical systems, with extensive use of modern operational mathematical techniques.

EE 511-512 Dynamic Control Analysis (3-0) (3-0)6

The principles of electronic devices used for control and measurement in applied science and engineering.

EE 513-514 Electromagnetic Theory (3-0) (3-0)6

Maxwell's equations, static and time-varying fields of charges and currents, energy and momentum relations, the wave equation, Poynting's vector, waveguides, special theory of relativity, retarded fields, radiation from accelerated charges and antennas, interaction of charged particles, and electromagnetic fields.

EE 521 Distributed Amplification (3-0)3
[EE 302, MA 312]

Basic concepts of distributed systems employing iterative structures; tube and transistor active elements in mixed lumped and distributed systems; and a discussion of millimicrosecond pulse measurement techniques.

EE 522 Parametric Amplification (3-0)3
[EE 302, MA 312]

Treatment of linear and nonlinear systems with varying parameters; solutions to the Mathieu-Hill differential equation; amplification with non-storage- and storage-type network elements; the pumped system with applications; and use of semiconductor devices as active network elements.

EE 529-530 Network Synthesis (3-0) (3-0)6

The formulation of the fundamentals of network theory; establishing realizability conditions and synthesis techniques for various classes of networks and network functions; and methods for realizing one or more networks whenever a function of the given class is prescribed.

EE 531-532 Seminar in Electronics (1-0) (1-0)2

Discussion by staff members and students of current journal publications and topics of current interest in electronic science, electronic engineering, and related areas of applied physics.

EE 533-534 Special Problems in Electronics Credits to be arranged

An opportunity for individual study, under the direction of a staff member, of topics in or related to electronic engineering.

EE 535-536 Graduate Research Credits to be arranged

Supervised research and thesis on some problem in electronic science, electronic engineering, or certain areas of applied physics.

Industrial Management

IM 241-242 Accounting I and II (2-3) (2-3)6

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

IM 307 Corporation Finance (3-0)3 [EC 202]

The financial aspects of the single proprietorship, partnership, and corporation. The financial function, sources of funds, financial statements, capitalization, and legal aspects of the corporation.

IM 308 Money and Banking (3-0)3 [EC 202]

The role of money and monetary policy in the United States. The banking structure, the Federal Reserve System, other financial institutions, and international monetary systems.

IM 321-322 Industrial Marketing I and II (3-0) (3-0)6 [EC 202]

Marketing principles and problems affecting the sale of industrial goods. Industrial market research, product research and development, pricing, and promotion.

IM 331 Industrial Advertising (3-0)3 [IM 321]

The principles and problems of advertising applied to the industrial field.

IM 334 International Business Operations (3-0)3 [IM 321]

Export-import trade, international operations, the European Common Market, American trade policy, and the problems of the United States' negative balance of payments.

IM 341-342 Accounting III and IV (3-0) (3-0)6 [IM 242]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

IM 344

Cost Accounting

(2-2)3

[IM 242]

Cost finding for manufactured goods. The necessity and principles of material control and accounting, direct labor accounting, overhead accounting, and distribution costing. Job order process and standard cost accounting systems are utilized.

IM 350

Introduction to Business Management

(3-0)3

[Not open to students majoring in Industrial Management]

Business organization and practice, including accounting, finance, marketing, personnel administration, and business organization.

IM 351

Motion and Time Study

(0-2)1

Psychology and methodology of industrial improvement. Work simplification and techniques of improvement, including motion economy, work space and plant layout, process charts, flow diagrams, and other current practices.

IM 360

Business Law

(3-0)3

The principles of commercial law, including contracts, agency, sales, partnerships, corporations, negotiable instruments, bailments and carriers, insurance, personal property, real property, suretyship and guarantee, and bankruptcy.

IM 371

Systems Engineering and Operations Research

(3-0)3

Analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

IM 411-412

Production Management I and II

(3-0) (3-0)6

The internal organization and productive processes of the manufacturer, including the management functions of planning, directing, and administration in relation to production. Plant layout, materials handling, inventory control, quality control, and time and motion study systems.

IM 421

Procurement

(3-0)3

[IM 322]

Purchasing procedure, quality control, inventory control, source selection, forward buying and speculation, and salvage operations as applied to the industrial enterprise.

IM 430

Marketing Management

(3-0)3

[IM 322]

An advanced study of problems in the field of marketing management, with emphasis on marketing research, competitive position, and marketing strategy and planning.

IM 441-442 Accounting V and VI (3-0) (3-0)6
[IM 342]

Advanced accounting, comprising the bridge between accounting principles and the actualities of large-volume modern business. Considers the measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

IM 444 Sales Management (3-0)3
[IM 322]

Management of the selling function in its broad aspect. Sales organization, compensation, selection, training, and supervision. Market research, product packaging and development, and distribution policies.

IM 461 Personnel Management (3-0)3

A comprehensive study of the techniques of recruiting, selecting, training, and placing of members of the work force, including such matters as employee health and safety, welfare and education, and wage and salary administration.

IM 470 Auditing (3-0)3
[IM 342]

Duties and responsibilities of the auditor, kinds of audits, and programs of audits; study of application of the theory and practice of accounting to auditing; internal control and its relationship to the audit program; and working papers of the auditor, statements, and reports.

IM 480 Accounting Systems (3-0)3
[IM 342]

Principles of systems designs; internal control, division of labor, routing of business papers, and procedural practices; systems modifications; and relationship of theory and practice of accounting to systems.

IM 483 or 484 Statistical Quality Control (3-0)3
[MA 383 or 384 or EC 212]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 502 Industrial Relations Seminar (3-0)3
[Permission of instructor]

This subject gives a small select group the opportunity to discuss and analyze current problems in industrial relations. Case material provides the basis of class work.

IM 504 Management Computer Operations (3-0)3
[Permission of instructor]

The use of digital computers in management problems.

[Permission of Department Head]

A subject designed to give the advanced Industrial Management student an opportunity to do research in an area of special interest under the direction of a member of the department.

Languages and Literature

LL 111-112 English I and II (3-0) (3-0)6

Training in the composition of extended exposition. Introduction to logic and to basic research techniques. Analysis and evaluation of collateral readings in the humanities. Introduction to literature.

LL 213 Introduction to English Literature (3-0)3

Interpretation and criticism of selections from the basic types of English literature—fiction, poetry, drama, biography, and the essay.

LL 214 Introduction to American Literature (3-0)3

Interpretation and criticism of selections from the basic types of American literature—fiction, poetry, drama, biography, and the essay.

LL 233 Comparative Literature (3-0)3

A consideration of at least six classics of western civilization as keys to the development of modern culture.

LL 234 Shakespeare (3-0)3

Shakespeare's chief tragedies, comedies, and chronicles. Lectures and discussions of Shakespeare and the nature of man.

LL 261-262 Elementary Technical German (3-0) (3-0)6

An introduction to the study of the German language to develop a reading knowledge of scientific German. Limited practice in pronunciation and writing. No credit given for first semester without second.

LL 263-264 Elementary Technical French (3-0) (3-0)6

An introduction to the study of the French language to develop a reading knowledge of scientific French. Students with less than two years of high-school French must take both semesters to receive credit. Students with two or more years of high-school French are not eligible for LL 263 but may enroll for credit in LL 264.

Graduate students may enroll in either or both semesters, but no credit will be granted.

LL 265-266 Elementary Technical Russian (3-0) (3-0)6

An introduction to the study of the Russian language to develop a reading knowledge of scientific Russian. Limited practice in pronunciation and writing. No credit given for first semester without second.

LL 361-362 Intermediate Technical German (3-0) (3-0)6
[LL 262]

Intended to increase vocabulary and reading knowledge of scientific German. Further practice in speaking and writing in scientific terminology. Either semester may be taken separately for credit.

LL 365-366 Literary and Conversational Russian (3-0) (3-0)6
[LL 266]

Practice in conversational idioms. Russian short stories and essays of moderate difficulty with explanatory notes and vocabulary, including some simplified versions of works by Lermontov, Pushkin, and Gogol. Either semester may be taken separately for credit.

Offered in alternate years; not offered in 1963-64.

LL 367-368 Literary and Conversational German (3-0) (3-0)6
[LL 262]

Contemporary German literature with concentration on a contrast and comparison of 20th-century German and American literary trends. The direct method is used, and only German is spoken in class.

LL 467 Advanced Seminar in Literary German (3-0)3
[LL 367-368]

Directed study in the works of two classical and two modern German writers. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

LL 468 Advanced Seminar in Literary German (3-0)3
[LL 367-368]

Directed study in the works of leading German authors, primarily in the field of nonfiction. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

LL 471 The Modern American Novel (3-0)3

A consideration of outstanding American novelists from 1920 to the present. Selected works of Faulkner, Fitzgerald, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3

The development of the novel in English literature from Conrad and Hardy through Huxley and Golding. Selected novels are read and discussed.

LL 473 World Drama (3-0)3

A general introduction to and survey of the main currents in world drama from its early beginnings in Greece to the modern plays of the European continent. Selected significant plays from the representative periods in the historical development of world theater are read and discussed.

LL 474 Modern Drama (3-0)3

An analysis of major forces in the theater from the time of Ibsen to the present. Selected representative plays of American and European dramatists.

LL 482 The American Short Story (3-0)3

A critical survey of the growth and development of the American short story. The works of Poe, Crane, Anderson, Hemingway, and Faulkner are among the writings considered.

Mathematics

MA 107 Calculus and Analytic Geometry (4-0)4

Functions and graphs, equations of straight lines, the differentiation and integration of algebraic functions together with applications involving related rates, differentials, maxima and minima, Mean Value Theorem, areas, volumes, lengths of curves, areas of surfaces of revolution, center of mass, the theorems of Pappas, pressure, and work.

MA 108 Calculus and Analytic Geometry (5-0)5

[MA 107]

The differentiation of exponential, logarithmic, and trigonometric functions; integration by parts, integration by partial fractions, integration by trigonometric substitution, and other integral forms; determinants, both second and higher order; properties of roots of higher-degree equations; the conics, translation and rotation of curves, hyperbolic and inverse hyperbolic functions, polar coordinates, parametric equations, differentiation of vectors, and tangential and normal components of velocity and acceleration.

MA 205 Calculus and Analytic Geometry (4-0)4
[MA 108]

The scalar and vector products of two or more vectors, solid analytic geometry, space curves, curvature, arc length, partial differentiation, directional derivatives, gradient, chain rule, total differential, the method of least squares, maxima and minima of independent variables, line integrals, multiple integration, and three-coordinate systems; series, including Maclaurin, Taylor, and Fourier series, indeterminate forms, and tests for convergence; and complex functions including the Argand diagram, DeMoivre's theorem, the Cauchy-Riemann equations, and logarithmic functions.

MA 206 Differential Equations (3-0)3
[MA 205]

The solution of ordinary differential equations and of partial differential equations of the first order and first degree and of forms in certain other orders and other degrees that lend themselves readily to solution. Practical applications to chemistry and engineering.

MA 301-302 Advanced Calculus (3-0) (3-0)6
[MA 206]

Ordinary differential equations, the Laplace transformation, numerical methods of solving differential equations, series solutions of differential equations, vector analysis, topics in higher dimensional calculus, partial differential equations, and complex variable theory.

MA 305 or 306 Theory of Equations (3-0)3
[MA 108]

Mathematical induction, complex numbers, integral and rational roots, solution by radicals, impossibility of certain geometrical constructions, number of real roots, isolation of a root, determinants, and approximate methods of solution.

MA 311-312 Engineering Mathematics (3-0) (3-0)6
[MA 206]

Ordinary differential equations, Laplace transformation, numerical methods of solving differential equations, series solutions of differential equations, boundary value problems and orthogonal functions, vector analysis, partial differential equations, partial differential equations of mathematical physics, and complex variable theory.

MA 355 or 356 Digital Computer Programming (1-2)1
[MA 206]

The programming of a high-speed digital computer. Selected practice problems related to the specialties of the class. Programs written by the students are tested on the Institute's digital computer.

MA 383 or 384	Statistical Methods	(3-0)3
	[MA 108]	

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

MA 405 or 406	Mathematical Statistics	(3-0)3
	[MA 205]	

Measurements of dispersion, theoretical frequency distributions, tests of goodness of fit and independence, partial and multiple correlations; permutations, combinations, and probability; game theory.

MA 433 or 434*	Matrix Algebra	(3-0)3
	[MA 205, PH 311]	

Algebra of vectors, matrices, and determinants; linear transformations; linear vector spaces; characteristic roots and reduction to diagonal form; quadratic forms; and applications to physics.

MA 459-460*	Digital Computer Programming and Numerical Analysis	(2-3) (2-3)6
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Basic and advanced programming techniques in the use of high-speed digital computers for the solution of scientific and engineering problems. The preparation and running of sample problems on the Institute's IBM 1620 computer and at least one other larger computer. Numerical analysis techniques include simultaneous equations, least squares data fit, interpolation, numerical solution of differential equations, and other matters.

MA 484*	Probabilities	(3-0)3
	[MA 302]	

Theory of arrangements; introduction to probabilities; Stirling's theorem; Bernoulli's theorem; random walk; continuous distributions; normal probability distribution; Poisson distribution; and elements of statistics.

MA 515 or 516	Methods of Applied Mathematics	(3-0)3
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The calculus of variations, integral equations, and applications.

MA 525 or 526	Modern Algebra	(3-0)3
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Topics in modern algebra, including number theory, equivalence relations, fields, integral domains, ideals, groups, Boolean algebras, sets and matrices.

MA 533 or 534 Matrix Theory (3-0)3

Linear vector spaces; the algebra of vectors and matrices; linear transformations, special matrices, and quadratic forms; characteristic roots and reduction to diagonal form; and applications to physics and quantum mechanics.

MA 537-538 **Group Theory** **(3-0) (3-0)6**

Elements of set theory; mappings, isomorphisms, and cardinality; semi-groups and groups; the theory of finite groups; general representation theory; and applications of group theory to quantum mechanics.

MA 541 or 542	Fourier Series and Boundary Value Problems [MA 206]	(3-0)3
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The Fourier series as a tool of analysis; Dirichlet's theorem; orthogonal functions; convergence tests; the Fourier integral; cylindrical and spherical harmonics; and boundary value problems.

MA 543 or 544 Partial Differential Equations I (3-0)3
[MA 302]

A study of set theory and Fourier series; ordinary differential equations in more than one variable; and partial differential equations of first and second order. Emphasis is placed on those equations which arise in physical investigations. Classification of equations.

MA 545 or 546 Partial Differential Equations II (3-0)3
[MA 543 or 544; MA 573 or 574]

Study of the wave, potential, and heat equations; the Cauchy problem; and dependence of solutions on boundary conditions.

MA 553 or 554	Tensor Analysis [MA 433 or 533]	(3-0)3
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The tensor concept; covariant and contravariant tensors; the metric tensor, associated tensors, and covariant differentiation; Euclidean and Riemannian manifolds; and applications to geometry and analytical mechanics.

MA 557-558	Computers [MA 302]	(3-2) (3-2)8
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The principles of analog and digital computers as a basis for assessing and planning their use in scientific work. Logic design, instrumentation, programming, and numerical analysis. A survey of well-known commercial analog and digital computers. Experience with the computers at the Institute and also a visit to a local computing center having different equipment, during which a course-programmed problem may be run.

MA 563 or 564 Projective Geometry (3-0)3
[MA 205]

An introduction to various non-Euclidean geometrics. Point sets on a line, line pencils, homogeneous coordinates, and the theory of conics and quadrics. Multidimensional geometry, Plucker coordinates, and correlations and collineations in space.

MA 573 or 574 Functions of a Complex Variable (3-0)3

Complex numbers, point sets, and elementary functions; an introduction to regular analytic functions; classification of singularities; and conformal mapping and applications.

MA 575 or 576 Transform Analysis of Linear Systems (3-0)3
[MA 302]

Mathematical theory of Laplace and Fourier transforms and their application to the analysis of linear systems. The expression of initial conditions, the relation of functions of time to corresponding functions of a complex variable, the relation of linear differential equations with constant coefficients to corresponding algebraic equations, and the interpretation of the behavior of a linear system by a study of its poles and zeros in the complex plane. Characterization of physical systems by transfer functions and the response of some physical systems to step, impulse, and sinusoidal inputs.

MA 585-586 Random Processes and Noise Theory (3-0) (3-0)6
[MA 302]

Principles of random noise theory and optimum filtering. Development of the concepts of correlation function and power spectra for the detection of signals in noise. Illustration of the theory in some applications of circuits and computers with emphasis on the formulation of the noise problem, its mathematical solution, and the interpretation of the results for proper design of systems.

MA 591 or 592 Graduate Thesis Credits to be arranged

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

Mechanical Engineering

ME 101 Engineering Graphics (1-2)1

Communication by graphic representation—orthographic and pictorial. Charts and graphs. Freehand and instrumental multiview drawing, dimensioning, engineering geometry, pictorial sketching, and projection.

ME 102 Engineering Graphics (1-2)1 [ME 101]

The use of graphics in the solution of problems. Visualization by descriptive geometry, and its exercise in vector geometry and intersections. Graphical calculus, nomography, and empirical equations.

ME 211 or 212 Applied Mechanics I (3-0)3 [MA 108, PH 103]

[For students of Mechanical and Textile Engineering only]

A development of fundamental ideas such as vectors, forces, and moments. A detailed treatment of the free body diagram concept and its application to resultants of force systems, laws of static equilibrium, friction forces, first and second moments, and various structures and machine parts.

ME 213 or 214 Applied Mechanics II (3-0)3 [ME 211 or 212]

[For students of Mechanical and Textile Engineering only]

A continuation of ME 211 or 212. The basic laws of kinematics of particles and rigid bodies which involve linear, angular, relative, and absolute motion; Newton's laws and their applications to the kinetics of rigid bodies in translation, rotation, and plane motion; and the principles of work, energy, impulse, and momentum.

ME 215 Engineering Mechanics I (3-0)3 [MA 108, PH 103]

[For students of Electrical Engineering only]

Statics and an introduction to mechanics of materials, including vectors; force systems; moments; friction; moment of inertia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 Engineering Mechanics II (3-0)3 [ME 215]

[For students of Electrical Engineering only]

Dynamics and mechanics of materials, including beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 261 or 262 Machine Tool Laboratory (1-2)1

Metals processing. Basic machine tools such as the lathe, shaper, drill-press, and milling machine, as well as the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, die-casting, welding, and forging.

ME 263 or 264 Metals Processing (1-2)1

Modern methods of manufacture, including some of the more recent developments such as ultrasonic and chemical milling, explosive forming, electrolytic grinding, etc. Also, the basic instruments used in metrology, i.e., hardness tester, optical flats, optical comparator, and others.

ME 311 Applied Mechanics III (3-0)3
[ME 211 or 212]

A basic subject in strength of materials. Fundamentals of stress and strain and their applications, including tension, compression, shear, and combined stresses; the Mohr circles for stress and strain; shearing force and bending moment diagrams; stresses and deflections of beams in bending; statically indeterminate problems; torsion of circular sections; and stresses in columns.

ME 313 Mechanics of Solids I (3-0)3
[For students majoring in Chemical Engineering, Paper Engineering, or
Plastics Technology]

Static and dynamic behavior of rigid systems. Statics of rigid bodies, energy principles, kinematics and dynamics of particles and rigid bodies, and introduction to vibrations.

ME 314 Mechanical Engineering Laboratory I (0-3)1

Experimental work in the various fields of mechanical engineering to gain an appreciation of measurable quantities, analytical approaches, and measuring equipment and techniques. Design, analysis, and synthesis of engineering systems are stressed throughout. The student is encouraged to devise his own experiments and to obtain and analyze the engineering data required for design.

ME 315 Applied Mechanics (3-0)3
[MA 108, PH 103]

[For students of Industrial Management and Paper Engineering only]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 317 or 318**Applied Mechanics IV****(3-0)3**

[ME 214]

The fundamental ideas of statics and dynamics applied to general systems with oscillatory motion. The kinematics of periodic motion; free, undamped, damped, and forced vibrations of systems with a single degree of freedom; energy methods and systems with multiple degrees of freedom; and tabular methods for calculation of natural frequencies.

ME 341**Thermodynamics****(3-0)3**

[MA 205, PH 205]

Heat and work, the thermodynamic system, the first law of thermodynamics, open and closed systems, and steady-state and unsteady-state flow; the pure substance, the perfect gas, heat capacities, and the equipartition of energy principle; the second law of thermodynamics, the concept of reversibility, heat engines, and the thermodynamic temperature scale; entropy and its relationship to probability, stability, and information; and availability and free energy.

ME 342**Thermodynamics****(3-0)3**

[ME 341]

Applications of the basic principles of thermodynamics, properties of thermodynamic media and their utilization, combustion processes, flow systems, and power plant cycles.

ME 343 or 344**Heat and Power****(3-0)3**

[MA 108, PH 104]

[Not open to students majoring in Electrical, Mechanical, or Textile Engineering]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 371 or 372**Strength of Materials****(3-0)3**

[ME 211 or 212; ME 315]

Stress fundamentals, strain bending moment and deflection, beam design, torsion, columns, combined stresses, reversals of stress, and impact.

ME 374**Plastics Mold Design and Construction****(1-2)1**

[ME 261 or 262]

Principles of mold design and construction. The machining and finishing operations of plastics, and actual laboratory work in the design and construction of simple molds.



Plastics Extrusion Laboratory

ME 375 or 376**Materials Science****(3-2)3**

[PH 206]

The dependence of the properties of materials in general on atomic and crystalline structure. X-ray diffraction; equilibrium and rate processes; interatomic attractive forces; diffusion; theory of dislocations; mechanical, electrical, electronic, magnetic, and thermal properties. Standard physical tests and assigned projects are performed in the laboratory.

ME 377**Elements of Materials Science****(2-0)2**

(Not open to students in Electrical, Mechanical, or Textile Engineering)

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, cold work, and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 378**Mechanics of Solids II****(3-0)3**

[For students majoring in Chemical Engineering, Paper Engineering, or Plastics Technology]

Static and dynamic behavior of deformable systems. Stress and strain, torsion, compound stresses, analysis of plane stress and strain, failure theories, statically indeterminate members, stability and buckling, and stresses and deformations in bodies under dynamic loading.

ME 381 or 382**Fluid Mechanics****(3-0)3**

[MA 205, PH 205]

Definitions and fluid properties, including force, mass, shear, and viscosity; fluid statics, comprising pressure, relative equilibrium, and fluid forces on submerged surfaces; fluid flow concepts and basic equations, e.g., continuity, Euler's, Bernoulli's, and momentum equations, reversibility and losses, and thermodynamic relations; dimensional analysis and dynamic similitude: π -theorem; viscous effects and fluid resistance, including Reynolds' number, boundary layer, drag on immersed bodies, duct losses, and the Moody diagram; compressible flow, e.g., Mach number, shock wave, and frictional and isentropic flow; closed and open conduit flow; fluid measurements, comprising velocity, flow rate (orifices, nozzles, weirs), and viscosity; water hammer, surge, cavitation, and turbomachinery.

ME 415**Mechanical Engineering Laboratory II****(0-3)1**

[ME 314]

Continuation of ME 314.

ME 416**Mechanical Engineering Laboratory III****(0-3)1**

(ME 415)

An individual project selected by the student in consultation with the staff. The project must include phases of design, construction, and analysis. Both a formal written report and an oral presentation are required.

ME 421-422**Machine Design****(2-3) (2-3)6**

[ME 214, ME 311]

The application of the principles of mechanics to the design of typical machine elements, such as shafts, springs, screws, belts, clutches, brakes, bearings, gears, and cams. Theories of failure and methods of establishing working stress levels are considered. The laboratory work consists of comprehensive projects that illustrate the close relationship between analysis and synthesis as they are applied to various machine design problems.

ME 431 or 432**Power Plant Systems****(2-3)3**

[ME 342]

Elements of the design of power plants. Capacities and operating specifications are determined for the equipment of a power plant designed to produce electricity and processing steam for a manufacturing industry. Operating costs are computed based upon current prices of power plant machinery, fuel, labor, and the various necessary supplies.

ME 443 or 444**Heat Transfer****(3-0)3**

[MA 206, ME 341, ME 382]

Modes of heat flow; combined heat transfer mechanism and the analogous electrical network; conduction (steady state and transient), including exact and approximate methods of analysis (flux plot, Schmidt plot, finite differences); radiation heat transfer; dimensional analysis, fluid flow, and boundary layer; Reynolds' analogy; Nusselt, Prandtl, Biot, Fourier, Graetz, and Grashof numbers; free convection; forced convection inside ducts and over exterior surfaces; heat transfer to boiling liquids and condensing vapors; and finned surfaces and heat exchangers.

ME 455 or 456 Information Processing Systems**(2-2)3**

[MA 356]

The use of electronic computing systems for the solution of engineering problems, with stress on symbolic programming methods. Student use of the IBM 1620 installation at the Institute is an integral part of the course.

ME 471 or 472 Experimental Stress Analysis**(2-2)3**

[MA 205, ME 311]

Photoelasticity, including introduction to theory of elasticity; stress separation by shear difference; arithmetic iteration; oblique incidence; lateral deformation; photoelastic coatings; mechanical, optical, and electrical strain gages; and brittle lacquer techniques. Analogies.

ME 475 or 476**Physical Metallurgy****(3-0)3**

[MA 206; ME 375 or 376]

A study of metals. Phase diagrams and transformations, the system carbon-iron, electrical and magnetic properties related to structure, thermal and optical properties, elasticity and plasticity (including creep), diffusion,

recovery, recrystallization, grain growth, hardening, and heat treatment. Interpretation of microphotographs of polished and etched specimens is stressed, as is the application of the theory to industrial problems involving the failure of metals in service.

ME 491 or 492 Engineering Systems (2-0)2

Application of fundamental engineering principles in the solution of design problems which involve more than one engineering discipline, with emphasis on costs, useful life, reliability, safety, esthetics, miniaturization, maintainability, and interchangeability.

ME 493 or 494 Industrial Instrumentation (2-0)2

[MA 108, PH 104]

[Not open to students majoring in Electrical, Mechanical, or Textile Engineering]

Modern methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level, and fluid flow; response characteristics of mechanical, electric, and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; closed-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

ME 495 Electromechanical Engineering (3-2)4

[EE 204, MA 206]

Characteristics of electromechanical transducers and their associated circuitry as employed in the measurement of acceleration, velocity, displacement, stress, strain, thickness, mass, weight, frequency, time, and level of intensity.

ME 496 Electromechanical Engineering (3-2)3

[ME 495]

Servomechanisms and their application to control problems, with emphasis on system analysis by block diagram using transfer function techniques, and the use of electrical analogs for analysis and design of mechanical systems.

ME 528 Kinematic Mechanism Synthesis (3-0)3

[ME 214]

Mechanism concepts; symbolic notations; coupler curves; and the Gruebler criterion. Planar linkage synthesis by geometric methods; synthesis of function generators and dwell linkages; and the Euler-Savary equation. Analytic methods of synthesis; Freudenstein's method; kinematics of spatial mechanisms; matrix representation of rotation; and matrix methods of analysis.

ME 541 or 542 Air Conditioning (2-3)2
[ME 342]

The principles of heating, ventilating, and refrigeration. The laboratory consists of design problems in the air conditioning of industrial buildings.

ME 555 or 556 Advanced Computer Problems (3-0)3
[ME 455 or 456, and permission of the instructor]

An opportunity for students familiar with computers to develop advanced problem applications of particular interest to them.

Nuclear Science and Engineering

NU 301 or 302 Nuclear Radiation and Radiological Safety (3-0)3

The basic physics of alpha, beta, and gamma radiation, with emphasis on the more practical considerations. The absorption and scattering of gamma radiation with applications to the design of shielding systems for protection of personnel, and effects of intense radiation on biological systems, structural materials, and chemical reactions.

NU 351 or 352 Nuclear Instrumentation I (2-4)3

Electronic pulse circuitry, including amplifiers, discriminators, counting, coincidence, and pulse height circuits; and the measurement of resolving and response times. Specific experiments in nuclear instrumentation.

NU 401-402 Nuclear Engineering (3-0) (3-0)6
[MA 301-302, PH 362]

Nuclear theory, with emphasis on the production and reactions of neutrons. The theory of nuclear fission; the diffusion and slowing down of neutrons; homogeneous and heterogeneous reactors; the analysis and control of nuclear reactors; neutron transport theory and multigroup theory; the design of nuclear reactors, with emphasis on the shielding of the core; and specific types of reactors such as swimming pool, water boiler, research, and power.

NU 403-404 Reactor Instrumentation (2-4) (2-4)6

Elements of servomechanisms; automatic control systems; electrical and electronic theory utilized in the measurement of reactor parameters such as reactivity, danger coefficients, and temperature coefficients; detection of neutron flux with fission, BF_3 , and ionization chambers; analysis and design of power-measuring and period-measuring instruments; and calibration of control rods and general reactor control devices.

NU 405-406 Reactor Theory (3-0) (3-0)6

Review of nuclear physics, interaction of neutrons with matter, nuclear fission, neutron chain reaction systems, neutron flux and interaction rates, diffusion of neutrons, slowing down of neutrons, Fermi theory of the bare thermal reactor, multiregion reactors, the group diffusion method, and reactor kinetics.

NU 451 or 452 Nuclear Instrumentation II (3-0)3
[PH 461]

The general nature of detection systems for electrons, protons, neutrons, photons, and alpha particles; the nuclear and electronic characteristics of Geiger, proportional, scintillation, and spark counters; and applications to specific experiments in nuclear physics.

NU 493-494 Nuclear Laboratory (1-6) (1-6)6
[Permission of instructor]

A laboratory course to accompany the senior subjects in the department and to serve as a vehicle for undergraduate experimental research in selected fields of nuclear science and engineering.

Paper

PA 201 Introduction to Paper Engineering (1-0)1

A study of major pulp and paper systems to provide sufficient background for more advanced courses, to stimulate an appreciation for the historical development of the industry, and to create an awareness of its current economic opportunities. Available as an elective to students in other major areas of study.

PA 301 Pulp Systems (3-0)3
[CH 211 and PA 201, or permission of instructor]

Lectures and problems concerning the technology of pulp manufacture by the groundwood, sulfite, alkaline, and semichemical processes. Bleaching methods are studied.

PA 302 Paper Systems (3-0)3
[CH 211]

Lectures and problems concerning the technology of paper manufacture. Stock preparation, filling and loading, sizing, coloring, special additives, paper machine operation, and finishing.

PA 303 Pulp Systems Laboratory (2-6)4
[CH 211]

This as well as subsequent laboratory work is designed with a research-type approach to develop the student's ability to plan and analyze the experimental work and to reach logical conclusions from the results. Studies of the principal wood, rag, and wastepaper pulps, with work in wood and pulp microscopy, bleaching, and evaluation of pulps for their papermaking value by physical and chemical testing methods. Detailed written and oral reports are required.

PA 304 Paper Systems Laboratory (1-6)3
[CH 211]

The fundamental processing techniques used in paper manufacture, including investigations of stock preparation, filling and loading, coloring, use of additives, and sheet formation. Detailed written and oral reports are required.

PA 403 Converting Processes (3-0)3
[PA 302, PA 304]

Lectures and problems concerning the technology of paper and paper-board conversion by mechanical, coating, impregnating, laminating, and printing processes.

PA 405 Converting Processes Laboratory (0-6)2
[PA 403, usually taken concurrently]

Study of, and practice in, the use of the common techniques employed in the paper and paperboard industry, with emphasis on the colloidal and rheological properties of materials used. Detailed written and oral reports are required.

PA 414 Paper Research Problems (1-6)3

A research problem connected with some phase of the pulp, paper-board, or converting industry is selected by the student in collaboration with the staff and an advisory committee from the industry. A literature survey is performed, and a preliminary report outlining the problem and the proposed investigation is submitted. Then the investigation is carried out, and a detailed formal report is written.

PA 501-502 Graduate Thesis Credits to be arranged

Every graduate student is required to prove his ability to carry on independent research by presenting a thesis on an approved subject.

Physics

PH 103 Physics (4-1)4

[MA 107 taken concurrently]

The principles of mechanics, including composition and resolution of vectors, statics, moments, rectilinear motion, Newton's second law, motion of a projectile, work and energy, impulse and momentum, circular motion, rotational kinematics and dynamics, elasticity, harmonic motion, hydrostatics, surface tension, hydrodynamics, and viscosity.

PH 104 Physics (4-2)4

[PH 103 or equivalent; MA 108 taken concurrently except by Industrial Management majors]

The basic principles of electricity and magnetism, including Coulomb's law, potential, d.c. circuits, the magnetic field, galvanometers, ammeters, voltmeters, wattmeters, the d.c. motor, magnetic field of a current and of a moving charge, induced electromotive force, capacitance and inductance, and magnetic properties of matter; transients in circuits containing inductance, capacitance, and resistance; thermoelectricity; ferromagnetism and ferroelectricity; and alternating currents, electromagnetic waves, and electronic phenomena.

PH 205 Physics (4-2)4

[MA 205 taken concurrently, PH 104]

Heat, sound, and optics, including the following: thermometry, quantity of heat, change of state, and work and heat; heat transfer, thermal properties of matter, and the first and second laws of thermodynamics; wave motion, vibrating systems, and acoustical phenomena; the nature and propagation of light; reflection and refraction at a single surface; lenses and lens aberrations; optical instruments; illumination; color; chromaticity diagrams; interference and diffraction; resolution; polarized light; and properties of crystals.

PH 206 Physics (4-2)4

[PH 205]

Modern physics, including the atomic nature of matter and electricity, variation of mass with velocity, isotopes, the nature of radiant energy, black bodies and the origin of the quantum theory, photoelectricity, spectra, Bohr's theory of the atom, X-ray spectra, waves associated with material particles, the spinning electron, Pauli's principle, magnetic moment of an atom, the periodic system and quantum numbers, molecular structure, radioactivity, elementary particles, scattering and absorption of particles and photons, transmutation, fission, reactors, fusion, cosmic rays, mesons, hyperons, and relativity.

PH 208 **Modern Physics** **(3-2)4**
[PH 205]

Charged particle motion in electromagnetic fields, black body radiation, the photoelectric effect, the special theory of relativity, the Bohr atom, quantum mechanics, X-ray scattering and absorption, Compton scattering, and the kinetic theory of gases.

PH 211 or 212 **Intermediate Mechanics I** **(3-0)3**
[MA 205 taken concurrently, PH 104]

Statics of systems of particles, center of gravity, principle of virtual work, rectilinear motion of a single particle, the linear oscillator, motion of a single particle in a central field, vector analysis, Stokes' theorem, and conservative forces.

PH 244 **Optical Instruments** **(1-2)2**
[PH 206 taken concurrently]

The basic laws of optics and their application to various optical instruments used in industry, such as the microscope, telescope, refractometer, and colorimeter. Considerable emphasis in the laboratory work is placed on the general use of the microscope.

PH 251 **Intermediate Electricity** **(3-3)4**
[MA 205 and PH 205 taken concurrently]

Electric field, potential, Gauss's law, dipoles, Poisson's and Laplace's equations, image problems, dielectric theory, energy, capacitance, force, electric current, d.c. circuits, steady magnetic fields, electromagnetic induction, magnetic properties of matter, L-C-R circuits, analysis of a.c. circuits, and Maxwell's equations.

PH 257 or 258 **Electrical Measurements** **(2-3)3**
[MA 205, PH 205]

Precision of measurements, zero-frequency and low-frequency measurements by both deflection and null methods, amplifiers and tube electrometers, oscillographs, measurements at high frequencies, magnetic measurements, and electrical measurements in mechanics, heat, acoustics, optics, and nuclear science.

PH 311 or 312 **Intermediate Mechanics II** **(3-0)3**
[PH 211 or 212]

Motion of systems of particles, generalized coordinates, Lagrange's equations, rigid body motion, the spinning top, the coupled oscillator, normal coordinates, and the vibrating string.

PH 321 or 322 Intermediate Thermodynamics (3-0)3
[CH 102, MA 206, PH 206]

Thermodynamic systems, the first and second laws of thermodynamics, the Carnot cycle, entropy, properties of pure substances, and various applications of thermodynamics.

PH 323 or 324 Introduction to Statistical Mechanics (3-0)3
[PH 311, PH 321]

Introduction to probability theory, classical Maxwell-Boltzmann statistics, classical statistical mechanics, statistical mechanical interpretation of thermodynamics, and applications to the kinetic theory of gases.

PH 343 or 344 Atomic Physics (3-1)3
[MA 206, PH 206]

The atomic models of Bohr and Sommerfeld. Quantum mechanics; one-electron, two-electron, and multielectron systems; doublet, triplet, and multiplet series; Zeeman effect; Paschen-Back effect; Stark effect; and correlation of theory with observation.

PH 347 or 348 Physical Optics (3-0)3
[PH 353 or 354]

The theoretical and experimental aspects of the phenomena of interference, diffraction, and polarization of electromagnetic waves, especially light and microwaves.

PH 353 or 354 Electromagnetic Theory (3-0)3
[EE 203; MA 301 or 302 taken concurrently]

Theory of electromagnetic fields. Polarization fields; solutions of Laplace's equation; magnetic potentials; Maxwell's equations and their application to guides and cavities; Fresnel's equations; and the Hertzian oscillator.

PH 361 or 362 Intermediate Nuclear Physics (3-0)3
[MA 206, PH 206]

Rutherford scattering, nuclear radius, the elements of wave mechanics, cross sections, and nuclear reactions.

PH 363 or 364 Introductory Nuclear Physics (3-0)3
[MA 206, PH 208]

[For students majoring in Nuclear Engineering]

Natural radioactivity, Bateman equations and graphical analysis, induced activity, Q values, binding energies, conservation laws, accelerators, cosmic rays, mesons, leptons, and baryons.

PH 365 or 366 Intermediate Nuclear Physics (3-0)3
[PH 363]

[For students majoring in Nuclear Engineering]

Rutherford scattering, center of mass coordinates, cross sections, Moseley law, quantum mechanics, barrier transmission, nuclear radii, and nuclear models.

PH 411-412* Quantum Theory (3-0) (3-0)6

[MA 433 and MA 484 taken concurrently; PH 311 or 312]

The beginnings of the quantum theory. The Bohr-Sommerfeld theory; wave-particle dualities and the uncertainty principle; the DeBroglie theory; basic principles of wave mechanics; Schrodinger's equation and applications; operators and observables; commuting properties of operators and their relationships to the uncertainty principle; mathematical theory of eigenfunctions, Fourier series, and the Fourier integral; matrix mechanics; perturbation theory by wave and matrix mechanics; and applications.

PH 431 or 432* Theory of Vibrations and Sound (3-0)3
[MA 301, PH 312]

Free, damped, and forced oscillations; forcing by pulses; coupled oscillations; the flexible string; end conditions; perturbations; the vibration of bars, membranes, and plates; sound waves; acoustic impedance; the radiation and scattering of sound; normal modes; and reverberation. Applications are stressed.

PH 461-462* Nuclear Physics (3-0) (3-0)6
[MA 302; PH 362 or 366]

Nuclear moments, parity and statistics, extranuclear effects of nucleus, effects of nuclear moments and parity on nucleus transitions, the deuteron, p-p and n-p scattering theory, alpha decay theory, beta decay systematics, and ionization of matter by charged particles.

PH 471-472* Solid-State Physics (3-0) (3-0)6
[PH 411-412 taken concurrently]

Crystal structure and X-ray and neutron diffraction; free electron model; band theory of solids; quantum mechanical considerations; lattice energy, lattice vibrations, and infrared absorption; lattice defects; thermal properties of solids; dielectric and magnetic properties; mechanical properties; and semiconductor crystals.

PH 493-494 Advanced Laboratory (1-3) (1-3)4
[Permission of instructor]

A laboratory course which accompanies the senior courses in the department and which may serve as a vehicle for undergraduate experimental research in selected fields of physics.

PH 495 or 496* Special Research Problems Credits to be arranged

[Permission of Head of Department and instructor]

Special problems in theoretical and experimental physics assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

PH 503-504 Reference Methods and Reference Materials (2-0) (2-0)4

The correct use of scientific libraries. Each student is given an individual assignment to find all accessible information on a particular topic, with special emphasis on the original research papers.

PH 509-510 Origin and Development of Modern Theories (3-0) (3-0)6

The history of the theory of atomic spectra, including X-ray spectra used as an illustrative example to explain the principles of scientific method.

PH 511-512 Classical Mechanics (3-0) (3-0)6

Lagrange's equations, Hamilton's principle, holonomic and non-holonomic constraints, the two-body problem, matrix formulation of rigid body motion, Hamilton's equations, principle of least action, canonical transformations, Hamilton-Jacobi theory, and the theory of small oscillations.

PH 513-514 Statistical Mechanics (3-0) (3-0)6
[MA 302, PH 324]

Classical statistics, the H-theorem, and Boltzmann's transport equation; quantum statistics, ensemble theory, and the ergodic theorem; and applications to thermodynamics, solid-state physics, and nuclear physics.

PH 515-516 Quantum Mechanics (3-0) (3-0)6

The quantum theory of measurement, spin and relativistic wave equations, the Dirac theory of the electron, Feynman diagrams, and selected topics in scattering.

PH 517 or 518 High-Energy Particles (3-0)3

The physics of high-energy particles, including the so-called strange particles.

PH 523 or 524 Low-Temperature Physics (3-3)4
[MA 302; PH 321 or 322]

The production of low temperatures; temperature measurement; liquid helium; superfluids and superconductors; paramagnetic salts; the magnetic temperature scale; nuclear polarization and alignment; thermal conductivity at low temperatures; the third law of thermodynamics; and adiabatic demagnetization.

PH 531 or 532 **Acoustics** **(3-3)4**
Not offered in 1963-64.

PH 533 or 534 **Crystal Vibrations** **(3-0)3**
[MA 302, MA 433, PH 472]

Interatomic forces in crystals; the theory of lattice vibrations for one-, two-, and three-dimensional systems; and applications of quantum mechanics and statistical mechanics to crystal systems.

PH 543 or 544 **Spectrographic Methods** **(2-3)3**
[PH 206]

The theory and application of the spectrograph for the qualitative and quantitative analysis of materials. The Bohr theory, quantum mechanics, atomic models, and the theoretical prediction of line and band spectra. In the laboratory individual problems are assigned to the students.

PH 545 or 546 **X-Ray Diffraction** **(2-3)3**

Theory of X-ray production; absorption; scattering by electrons and atoms; crystallographic notation; Laue equations; and determination of crystal structure. For those whose background interests involve fibers, some opportunity for investigation of these is offered in the laboratory work.

PH 547 or 548 **Electron Microscopy and
Electron Diffraction** **(2-3)3**
[PH 206]

Analogies with optics; electrostatic and magnetic lenses; electron trajectories; the scattering of electrons; electron diffraction: wave properties of the electron and diffraction patterns; vacuum techniques; thin films by vacuum evaporation and electropolishing; specimen preparation; and photographic techniques.

PH 549 or 550 **Infrared Radiation** **(2-3)3**

The laws and theories of black body radiation, including those of Planck, Wien, and Stefan-Boltzmann, are thoroughly analyzed. Optical systems and infrared properties of materials are evaluated. Detector systems, including thermal photographic, photoelectric, and photoconductive are considered. The laboratory experiments are designed to enrich and to explore further the lecture theories. Experiments include a study of the radiation laws, measurements of optical properties of materials, and determinations of spectral response and detectivity of detectors, time constant measurements, and detector area and detector temperature effects.

PH 533 or 554 Piezoelectricity and Ferroelectricity (3-3)4

Crystallographic bases of piezoelectricity, crystal elasticity, rotated axes, modes of vibration; behavior and interactions of the elastic, dielectric, and piezoelectric coefficients; ferroelectric crystals, domain structure, transitions between phases, free and clamped states; and applications of piezoelectric and ferroelectric crystals.

PH 555 or 556 Plasma Physics (3-0)3
[PH 353]

A mechanistic approach to the study of ion behavior and associated stability problems in electric and magnetic fields; the development of the hydromagnetic equations from the Boltzmann transport equation and Maxwell's equations; the consideration of problems associated with the confinement of a plasma and the extraction of energy therefrom; the measurement of parameters associated with ions in electric and magnetic fields.

PH 561 or 562 Nuclear Physics (3-0)3
[PH 462]

A theoretical course treating the general aspects of nuclear reactions. Alpha and beta decay. Nuclear models and recent advances in nuclear physics.

PH 563 or 564 Microwave Spectroscopy (3-3)4
Not offered in 1963-64.

**PH 565 or 566 Nuclear and Electron Spin
Resonance Phenomena (3-3)4**
[PH 411-412 taken concurrently]

Introduction to crystal field theory and electron spin resonance; coupling of angular momenta; nuclear electric quadrupole and magnetic resonance; application to gases, liquids, and crystals; and a survey of experimental techniques.

PH 567 or 568 Neutron Diffraction Analysis (3-0)3

The diffraction of neutrons in crystals and its applications in the determination of lattice structures and magnetic moments.

PH 575-576 Problems in Solid-State Physics (3-0) (3-3)7

Quantum mechanics and specific heats, lattice energy, elastic coefficients, applications of statistical mechanics, ferroelectric crystals, diamagnetism and paramagnetism, Brillouin zones, Hume-Rothery rules, order-disorder transformations, semiconductors, ferromagnetism and anti-ferromagnetism, ferrimagnetism, magnet relaxation and resonance, superconductivity, lattice vacancies, diffusion, color centers, excitons, dislocations, and thermal and electrical conductivity at low temperatures.

PH 577-578 Thermodynamics of Solids (3-0) (3-0)6

Thermodynamics of first- and second-order phase changes; lattice energy and vibration spectrum; the Einstein-Debye model; nonideal solid solutions; order-disorder phenomena; crystal interfaces and imperfections; and applications to metals and semiconductors.

PH 581 or 582 Information Theory (3-0)3

A definition of information and its identification with entropy; a critical examination of codes and written and spoken languages; the Tuller-Shannon formula and the capacity of channels with noise; and autocorrelation techniques and their application. Physical analogs of communications problems are stressed throughout.

PH 583-584 Relativity Theory (3-0) (3-0)6

Invariance of physical laws; tensor formulation of the special theory of relativity and applications; and the general theory of relativity.

PH 585-586 Classical Field Theory (3-0) (3-0)6

The theory of electromagnetic fields; elements of special relativity; the covariant formulation of Maxwell's equations; applications such as the classical treatment of the field of moving charges, radiation, scattering, and physical optics; and introduction to gravitational fields.

PH 589 or 590 Quantum Field Theory (3-0)3

Not offered in 1963-64.

PH 591 or 592 Graduate Thesis Credits to be arranged

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

Plastics

PL 201-202 Plastics Technology (2-0) (2-0)4

A descriptive subject to acquaint the student with plastics as a class of materials. The history, definitions, classes, properties, and applications of plastics.

PL 301-302 Plastics Technology (2-2) (2-2)6
[PL 201-202]

Raw materials and manufacturing processes. Methods of processing plastics materials, including compounding, molding, casting, extruding, laminating, fabricating, and finishing. Evaluation and development of typical plastics problems. Laboratory instruction in the processing and fabrication of plastics materials.

PL 401-402 Plastics Technology (2-3) (2-3)6
[PL 301-302]

Application of plastics as engineering materials. Product, equipment, and mold design. Correlation of composition, processing, and fabrication with product design and applications. Continuation of laboratory instruction in processing, molding, and fabrication.

PL 403-404 Properties of Polymers (2-3) (2-3)6
[Open to seniors only]

Correlation of composition and structure with important engineering properties of plastics; environmental conditioning and effects of types of loading in evaluation of plastics materials; the theory of testing; critical examination of testing techniques, equipment, and standard ASTM methods of evaluating mechanical, thermal, electrical, and optical properties.

PL 406 Plastics Quality Procedures (3-0)3
[MA 383 or 384]

Basic techniques of maintaining quality in the manufacture of plastic products. Quality assurance of incoming material and outgoing products as well as the methods of controlling process quality. Description of methods used in calculating tolerances, meeting specifications, and determining reliability.

PL 411-412 Plastics Seminar (1-0) (1-0)2
[Open to seniors only]

Informal discussions, based on literature study conducted by the individual, of topics in, or related to, plastics technology.

Social Sciences

SS 102 Foundations of National Power (2-0)2

An examination of the nature of world politics from the points of view of various theories, followed by analysis of the elements, organization, strategies, and controls of international politics through a series of case studies drawn from past and current history.

SS 223-224 The United States Since 1865 (2-0) (2-0)4

A study of the advancement of the American people from the Reconstruction era to the present. With special permission the first semester may be taken alone for credit.

SS 225 Europe: 1789-1914 (3-0)3

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the French Revolution, the Industrial Revolution, social and political reforms, the rise of nationalism and imperialism, and the background of World War I.

SS 226 Europe Since 1914 (3-0)3

A review of the backgrounds of both World Wars and the postwar periods, with emphasis on such topics as the rise and development of totalitarianism, postwar efforts to establish international agencies, and changes in economic, political, and social institutions.

SS 301 The Government of the United States I (3-0)3

Political power, its conditions, uses, and abuses, with emphasis on the basis of power and the structure in the United States.

SS 302 The Government of the United States II (3-0)3

The structure and functions of the American government, particularly the functioning of the executive, legislative, and judicial branches and their interaction with interest groups, political parties, and the bureaucracy.

SS 303 Psychology I (3-0)3

The place of psychology in the life of the individual and society, with emphasis on the psychological bases of behavior and attitude in their relations to personal, industrial, and community experiences.

SS 304 Psychology II (3-0)3

[SS 303 and permission of instructor]

The interpretation of interpersonal behavior. This subject is organized around group meetings with discussions of cases involving interaction between individuals. Members of the group learn to interpret behavior from observation of the reaction of other members, reading assignments, self analysis, and periodic interviews with the instructor on the member's behavior interpretations.

SS 305 or 306 Sociology (3-0)3

The principles of sociology, including the development of man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 371 or 372 American Civilization to 1865 (3-0)3

A study of the development of national consciousness in America through a review of the evolution of economic, political, and social institutions and their influences upon U. S. culture.

SS 403 Foundations of National Power (3-0)3
[For Advanced AFROTC Cadets only]

An analysis of the relationships between the physical and cultural environment on one hand and differentiated political space on the other. Through the study of these relationships the course provides an understanding of the bases for national strategy in times of both peace and war, since the concern of national strategy is to make optimum use of all the resources of a nation to realize national policy.

SS 459 or 460 International Relations (3-0)3

An analysis of war as the crucial problem of world politics, as a domestic social institution, and in light of the development of nuclear weapons. The causes and functions of war in history and theory, its effects on the individual and society, efforts to control it, and the ethical problems raised by it are discussed in terms of conditions before the nuclear age and under the impacts of contemporary developments.

SS 470 Comparative Modern Governments (3-0)3

Twentieth-century political thought and the structure and functions of government in democratic and totalitarian systems, with emphasis on the governments of France, Germany, Great Britain, and the Soviet Union.

SS 471 or 472 Foreign Policy of the United States (3-0)3

American foreign policy since the founding of the Republic, with particular attention to the influences of both World Wars and the role of the United States in the postwar periods.

SS 477 or 478 Twentieth-Century Russia (3-0)3

The objective of this subject is twofold: to give the student an understanding of the Russian people, the Empire, and the Soviet Union through a study of backgrounds, and to make possible a comprehension of the structure, aims, and methods of the Soviet regime and its present role in world affairs.

SS 479 or 480 The Far East Since 1900 (3-0)3

Basic historical and cultural backgrounds of the peoples of East Asia surveyed as a preface to a study of the economic, political, and social development of the mainland and island states, with emphasis on the interests and policies of European nations and the United States.

Contributions of the ancient Greeks to our culture. The influences of Greek thought, arts, and politics studied through selected readings and discussions in seminar meetings.

A survey in the history of ideas in the West. Political philosophy and social criticism by writers whose works have been instrumental in forming modern ideologies, with particular emphasis on the political and social theories of Plato, Aristotle, St. Augustine, St. Thomas Aquinas, Luther, and Calvin.

A survey in the development of modern ideologies. An examination of selections of writings from authors whose impact is evident in contemporary political and social thought, with particular emphasis on the philosophies of early Liberalism, Social Darwinism, various forms of Communism, and democracy.

Roman contributions to western culture and politics, with emphasis on Roman legal and governmental concepts and institutions.

The structure and chemical reactions of linear high polymers of importance in the field of natural and synthetic fibers; the chemical and physical structure of polymers and fibers; the relation of molecular length, orientation, crystallinity, intermolecular attractions, side chains, and flexibility of polymers to the physical properties of fibers; and chemical reactions of polymers and their effects on fibers.

Unit operations involved in the manipulations and processing of fibers, yarns, and fabrics.

Conversions of fabrics from the gray state for utility, serviceability, or appearance. Stress is placed both on the chemical phases and on essential engineering principles. Lectures, seminars, and laboratory workshops.

TC 412 **Chemical Technology of Finishing II** **(3-2)4**
Continuation of TC 411.

TC 422 **Chemical Textile Testing** **(3-0)3**

Qualitative and quantitative methods for determining fiber content, finishing agents, and dyestuffs, including optical methods of analysis and evaluation.

TC 502 **Theory of Dyeing** **(3-4)4**

Mechanisms of reactions in the dyeing of fibers which emphasize basic physical and chemical variables affecting equilibria, rates of dyeing, and diffusion. Quantitative studies on the kinetics and equilibria of dyeing reactions are conducted in the laboratory.

TC 505 **Physical Chemistry of Dyeing** **(3-0)3**

Lectures and exercises on the physicochemical principles involved in the application of dyestuffs to textile materials, including both the thermodynamics and kinetics of dyeing.

TC 541-542 **Graduate Thesis** **Credits to be arranged**

An independent investigation of a problem in textile chemistry in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

TC 555-556 **Textile Chemistry Graduate Seminar** **(2-0) (2-0)4**

A series of informal discussions of current problems in research and technology in the textile chemistry field. Special investigations of the literature serve as a source of seminar topics.

Textiles

TE 361 **Textile Systems I** **(4-4)4**

The elements of fiber preparation, yarn manufacture by the various common systems, weaving, and knitting presented in an analytical, operational units manner, regardless of the fiber involved. Systems components, interrelationships, and commonness of function as well as the structural analysis, design, and synthesis of yarns and fabrics studied in terms of a mechanical frame of reference. Laboratory time is devoted to demonstrations of basic concepts only.

TE 362**Textile Systems II**
[TE 361]**(4-2)4**

A study and analysis of the processing of fabric from the loom to the finished state, regardless of fabric construction or fiber content, and including design considerations influencing major operational systems of purification, dyeing or printing, and finishing. Major emphasis is placed on the mechanical engineering aspects of the systems, with the necessary chemical aspects required to supplement this approach.

TE 411-412 Fundamentals of Textiles — Yarns (2-2) (2-2)6

Designed to familiarize students with the basic machines and techniques for the production of yarns regardless of the fibers and/or production systems used. Primary emphasis is upon the mechanical principles employed.

TE 431-432 Fundamentals of Textiles — Fabrics (2-2) (2-2)6

Designed to familiarize students with the basic machines and techniques for the production of fabrics regardless of the fibers and/or yarns employed, from the preparation of yarns for fabrication to the actions and modifications available for the production of fabrics. Primary emphasis is upon the mechanical principles employed.

TE 459-460 Technology of Finishing (3-1) (1-2)5

Lectures and laboratory workshops in the major engineering and chemical considerations necessary to finish fabrics of all fibers. The engineering aspects are stressed.

TE 471 Textile Evaluation (2-3)3

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equilibrium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 474 Instrumentation for Textiles (2-2)3
[EE 204]

A study of indicating and recording instruments used to measure such common textile process variables as pressure, temperature, humidity, liquid level, fluid flow, etc. Response characteristics of mechanical, electrical, and electronic systems, and process characteristics and their effects upon the selection of the correct mode of control.

TE 482 Application of Scientific Methods to (3-0)3
Textile Processes
[MA 206, ME 341]

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483-484* Engineering Design of Textile Structures (3-0) (3-0)6
[MA 205, TE 362]

This subject correlates engineering properties of textile materials, engineering principles, and textile processing in the design of textile structures with desired properties. The geometry of yarns and fabrics; design of textile structures for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes which the end use imposes; analyses of load-elongation diagrams of textile structural material.

TE 501-502 Structure and Properties of Fibers (3-0) (3-0)6
[Permission of instructor]

The molecular structure and arrangements of molecules in fibers are considered with respect to giving a foundation to the understanding of the physical and mechanical properties and behavior of these textile raw materials. These properties are examined from a fundamental viewpoint so that a sound approach to the technological utilization of fibers in textiles can be established. Such aspects as polymer structure, order, intermolecular forces, and flexibility, as they relate to stress-strain characteristics, viscoelastic behavior, etc., are discussed as well as the effects of environmental conditions on these factors. An introduction is made to the interrelation between fiber properties and yarn and fabric geometry in determining the behavior of textiles.

TE 503 or 504 Technology of Cotton Fibers (2-2)3
[Permission of instructor]

Effects of various chemical, mechanical, and growth modifications of cotton on the chemical, physical, and processing properties of the cotton fiber. Problems are assigned for laboratory evaluation, and a paper for class delivery is required of each student.

TE 517 or 518 Product Quality: Cotton (2-2)2
System Yarns
[Permission of instructor]

Devoted to a study and analysis of product defects in the manufacture of yarns on cotton system machinery. Procedures necessary to avoid the defects are studied, and the diagnostic ability of the student to recognize and remedy defects is developed.

TE 519 or 520 Multifiber Processing: Cotton (2-2)2
System Yarns
[Permission of instructor]

The blending and processing of various fibers utilizing cotton system machinery, with emphasis upon fiber properties and yarn characteristics.

TE 537 or 538 Fundamentals of Jacquard Fabrics (1-1)1
[Permission of instructor]

Sketching of original designs as applied to particular Jacquard fabrics, transfer of design to cross-section design paper, choice of weave structure for both the background and foreground, cutting and lacing of cards, and weaving of sample lengths of fabric.

TE 539 or 540 Complex Woven Structures (2-1)2

A study of Leavers lace design and production theory, production machinery, and manufacture. The same aspects of Schiffli embroidery are covered, as well as the fundamentals pertaining to chenille, Wilton, Brussels, tapestry, velvet, and Axminster carpets.

TE 545 or 546 Weaving Laboratory (0-3)1
[Permission of instructor]

Designed to provide additional time for the student in the weaving laboratory so that greater familiarization with the operation of various loom mechanisms may be acquired.

TE 571 Textile Microscopy (2-3)3

The principles involved in the use of the microscope for the qualitative and quantitative estimation of the morphological, physical, and chemical properties of textile materials.

TE 574 Mechanical Testing of Textiles (2-3)3

Thickness and compressional measurements, stress-strain-time phenomena of viscoelastic textile materials, Vibroscope theory and techniques, yarn uniformity, thermal determination, and friction evaluation are among the major topics covered. Emphasis is placed on current literature search assignments and the preparation of a student paper on a selected topic within the scope of the subject.

TE 585 Textile Plants Organization — Yarns (3-0)3

Designed to correlate the various aspects of yarn production. Emphasis is placed upon the need for proper balance among machinery elements for the production of specific yarn types. Consideration of machinery layouts for efficient and economic operation of the total yarn establishment, with stress on the various calculations involved. Considerable use is made of the case history technique of presentation.

TE 586 Textile Plants Organization — Fabrics (3-0)3

Similar in concept to TE 585 except that the subject pertains to the production of fabrics.

TE 590 Graduate Seminar (2-0)0

Introduction to thesis material and thesis preparation.

TE 591-592 Thesis Seminar (2-0) (2-0)2

Required of all graduate students in Textile Engineering during their thesis year. Devoted to problems in the preparation and presentation of research work, with illustrative material drawn from thesis work in process.

**TE 593-594 Graduate Thesis Credits to be
arranged**

Each graduate student in Textile Engineering is required to submit a thesis which shows ability and originality in the solution and presentation of a research project.

THE GRADUATE SCHOOL

INTRODUCTION

The Lowell Technological Institute Graduate School, founded in 1935, offers the degree of Master of Science in the following fields:

- Chemistry
- Electrical Engineering
- Leather Chemistry
- Mathematics
- Paper Engineering
- Physics
- Textile Chemistry
- Textile Technology

In addition the School offers a program leading to the Doctor of Philosophy degree in Chemistry with options in organic and physical chemistry.

Because of the varied objectives of the graduate students, each specific course of study is arrived at through consultation with the student's graduate adviser or advisory committee. Each program includes an original thesis.

ADMISSION

General Admission

To be eligible for admission to the Graduate School, an applicant must have received a bachelor's degree in an acceptable four-year course in which he has maintained a uniformly high scholastic rating. Both the quality and quantity of previous training are considered. Selection of applicants admitted is based upon their ability to pursue graduate work of high quality.

Special Student Status

An applicant who meets the general admission requirements but who wishes to concentrate on specific subjects or special research programs may request special student status. Acceptance is contingent upon the consent of the instructor in charge of each subject to which admission is desired, and the work does not lead to a degree.

Normally a special student may not change his status to that of a student working for a graduate degree. If a special student wishes to work for a degree, he must apply in writing to the Director of the Graduate School. If the application for change in status is approved, all of the credit earned as a special student may not necessarily be allowed for degree credit.



Paper Engineering Laboratory



Textile Engineering Laboratory

Provisional Status

An applicant for admission who is unable to meet all the requirements for general admission may be accepted provisionally if he satisfies the department in which he wishes to enroll that he is probably able to pursue graduate studies successfully.

The status of a provisional graduate student may be changed to full graduate status upon demonstration of his ability to pursue graduate studies successfully as measured by the completion of his first semester's work with a minimum of a B— average in subjects taken for credit toward the graduate degree.

Application Procedure

Applications may be obtained from the Office of the Graduate School. They should be completed and returned to the Director of the Graduate School not later than June 1 preceding the fall term in which the applicant wishes to enroll. Applications must be supported by letters from at least two persons qualified to judge the ability of the applicant to carry on graduate work and research. The letters should be sent directly from these persons to the Graduate School.

Transcripts of all undergraduate records (and graduate, if any) must be sent directly to the Office of the Graduate School by the institutions which the applicant has previously attended. All transcripts must be official, with appropriate seals and signatures. Records, descriptions of subjects, and letters must be in English. Each subject must be described in terms of content, scope, number of hours per week, and number of weeks duration. Lecture and laboratory time should be properly distinguished. If a catalogue giving such descriptions in English is available, the subjects taken may be clearly marked in a copy sent to the Graduate School.

Credit may be given for graduate subjects taken at other colleges if the grade received is at least B and if these subjects were not used in earning another degree. All applicants must submit an additional copy of transcripts which include the subjects for which transfer credit is desired. Not more than 10 credit hours for the master's degree or more than 22 credit hours for the doctor's degree may be transferred. No transfer credit can be offered for the thesis requirement for any graduate degree. Transfer credit for subjects taken at other colleges before initial enrollment at Lowell Technological Institute must be cleared within four weeks after the student's first registration. No transfer credit for such subjects is given after this period.

In addition to making application for admission and having transcripts and letters sent, the applicant must take the Graduate Record Aptitude Test and have the results sent to the Director of the Graduate School. Information regarding the Graduate Record Aptitude Test may be obtained from Educational Testing Service, 20 Nassau Street, Princeton,

N. J., or Box 27896, Los Angeles 27, Cal., whichever office is nearer to the applicant.

Because most subjects are presented in lecture form, students from other countries should have a reasonably fluent command of the English language before applying for admission. All students from countries where English is not the national language must pass an English Language Proficiency Test before they can be accepted into the Graduate School. This test may be taken at any U. S. Consulate office.

Except in unusual circumstances, applications are acted upon and the applicant is notified of the decision by July 1. Foreign applicants are urged to make application as early as possible so as to leave enough time for visa and other arrangements to be made.

EXPENSES

Tuition (per year)	
U.S. citizens who are residents of Massachusetts	\$200
U.S. citizens who are residents of other states	300
All others	550
Student Activity and Insurance Fund (per year)	43
Commencement Fee	15

In addition, every graduate student is required to bear the cost of binding at least two copies of his thesis for the Institute's files. Some divisions may require more than two bound copies. Students are not permitted to register for thesis work until these fees have been paid at the library.

FELLOWSHIPS

Teaching Fellowships

A limited number of part-time instructorships are available to qualified students working toward a graduate degree. Stipends range from \$1500 to approximately \$2500 per academic year, depending on the nature of the appointment, and reappointment in succeeding years is contingent upon satisfactory performance of duties. Appointees are expected to carry up to a half-time teaching load primarily involving supervision of undergraduate laboratories and review sections.

Research Fellowships

A few research fellowships are available to qualified students through industrial grants. Appointees are expected to devote full time to study and research. Appointments are made about June 1 for the next academic year.

National Science Foundation Cooperative Graduate Fellowships

The Institute is a participant in the National Science Foundation's Cooperative Graduate Fellowship Program. These fellowships are awarded on the basis of ability. Candidates must be citizens of the United States on or before March 1 following the submission of their applications and must be admitted to full graduate status by the Institute prior to beginning their fellowship tenures.

The stipend provided by the NSF for Cooperative Graduate Fellows is \$2200-\$3000 for those on a tenure of 12 months and \$1650-\$2250 for those on a tenure of nine months. In addition to the stipend, the NSF pays all tuition and fees to the Institute.

One of the requirements for making application for an NSF Fellowship is to take the Educational Testing Service Graduate Record Examinations (Aptitude Test and one Advanced Test in the area of specialization). Because the deadline for applying for the fellowships is in early November, it is important to make arrangements to take these tests early.

MASTER OF SCIENCE DEGREE PROGRAMS

Chemistry

This program provides opportunity for advanced study and research training in chemistry, both general and specialized. Provision also is made for the student to elect certain advanced subjects in related fields of mathematics, physics, and engineering.

Evaluation Examination—During the weeks of registration each entering student must present himself for four three-hour written evaluation examinations in the fields of organic chemistry, physical chemistry, inorganic chemistry, and analytical chemistry. In addition he must take a laboratory proficiency examination. These examinations are scheduled and administered by the Department of Chemistry, and the results serve as a guide for the student and advisory committee in planning the program of study. All entering students must take these examinations regardless of previous training.

Subject Requirements—Of the 20-credit minimum, exclusive of thesis and seminar, required in listed subjects (see Requirements for Graduation) a minimum of 15 credits must be taken in chemistry. Of these not more than 12 credits may be taken in approved undergraduate subjects, although normally credit is not allowed for undergraduate subjects in the major field of specialization, e.g., organic, physical, inorganic. Recommended subjects include CH 423-424*, CH 431-432*, CH 443-444*, and all 500 courses in chemistry. Each graduate program must include subjects in organic chemistry, inorganic chemistry, and physical chemistry. All students must take CH 507-508, Chemistry Seminar. The remaining credits (five or more) may be taken in chemistry or in a related field such as physics,

mathematics, or engineering. All subjects must be approved by the student's advisory committee.

Language Requirements—The student must demonstrate his ability to read technical German.

Advisory Committee—The development of the student's program of study is the responsibility of an advisory committee consisting of three members from the faculty of the Division of Chemistry and Applied Chemistry. This committee is appointed by the Director of the Graduate School upon the recommendation of the division chairman and includes the thesis supervisor.

Thesis Examination—Each candidate for the Master of Science degree in Chemistry, upon completion of his thesis, must present himself for an oral examination in the field of his thesis before an examination committee appointed by the Director of the Graduate School and consisting of his advisory committee and any additional faculty members desired by the Director. While only members of the examination committee and the Director of the Graduate School may conduct the examination, all faculty members may attend. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the Director of the Graduate School at least one month prior to the close of the last semester. Each student has the right to one re-examination within a period of one year.

Electrical Engineering

This graduate program offers to a limited number of selected students opportunity for individualized work in the more advanced areas of electronics with emphasis on analytic methods of analysis and synthesis.

Leather Chemistry

Opportunity for graduate research in Leather Chemistry is provided through this program. In general only those students either possessing the B.S. degree in Chemistry or having a strong background in chemistry are acceptable as candidates for the M.S. degree.

The curriculum in Leather Chemistry is similar to that required for the M.S. degree in Chemistry, and subject requirements are identical. No language requirement is involved, but CH 507-508, Chemistry Seminar, must be taken each semester the student is in residence. Opportunity is provided for conducting research in chemistry as applied to the composition and technology of leather, and laboratory facilities for processing and testing leather are available.

Each student upon entering the curriculum must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry.

Thesis Examination—Upon completion of the thesis, each candidate for the degree of Master of Science in Leather Chemistry must present himself for an oral examination in the field of his thesis to an examination committee appointed by the Director of the Graduate School. This examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester.

Mathematics (see **Physics and Mathematics**)

Paper Engineering

The graduate program in Paper Engineering is for the purpose of giving advanced work in papermaking, paper-converting, or allied fields.

The Paper Engineering Department will consider graduate students from three different sources:

- (a) graduates of the Lowell Technological Institute B.S. Paper Engineering course;
- (b) paper engineering B.S. and M.S. graduates of other schools;
- (c) general B.S. and M.S. engineering graduates with no previous paper training.

Students with the backgrounds given under (a) and (b) should be able to complete the work in one academic year. Students in group (c) should be able to complete the degree requirements in two academic years.

In the following suggested curriculum those subjects designated by a dagger represent minimum degree requirements.

First Semester			
CH	503†	Chemistry of High Polymers	(3-0)3
PA	301	Pulp Systems	(3-0)3
PA	303	Pulp Systems Laboratory	(2-6)4
		Technical Elective†	(3-0)3
Total hours			(11-6)13
Second Semester			
CH	334	Colloid Chemistry	(3-0)3
CH	504†	Chemistry of High Polymers	(3-0)3
CHE	204	Industrial Stoichiometry	(3-0)3
PA	302	Paper Systems	(3-0)3
PA	304	Paper Systems Laboratory	(1-6)3
Total hours			(13-6)15
Third Semester			
PA	403	Converting Processes	(3-0)3
PA	405	Converting Processes Laboratory	(0-6)2
PA	501†	Graduate Thesis	(0-12)4
		Two Technical Electives†	(6-0)6
Total hours			(9-18)15

Fourth Semester

CH	512†	Physical Chemistry of Surface-active Agents	(2-0)2
CH	538†	Rheology	(2-0)2
ME	382	Fluid Mechanics	(3-0)3
PA	502†	Graduate Thesis	(0-15)5
		Technical Elective†	(3-0)3
			<hr/>
			Total hours (10-15)15

Additional undergraduate subjects may be required of students who have deficiencies in their prior training. Technical electives generally lie in the area of chemistry, applied chemistry, and mathematics and must be approved by the head of the Department of Paper Engineering.

Physics and Mathematics

The graduate programs in Physics and Mathematics provide an opportunity for advanced study and the development of research capacity in physics or mathematics or both. The laboratories of the department are well set up for investigations in crystal physics and other aspects of solid-state physics, with excellent equipment in X-rays, spectroscopy, and electron microscopy. Equipment in nuclear physics is constantly being added.

Subject Requirements—Of the 20-credit minimum, exclusive of thesis, required in listed courses (see Requirements for Graduation) 15 credits must be taken in physics and mathematics. The remaining credits (five or more) may be taken in a related field. Of the total credits at least 12 must be in subjects numbered 500 and above. A reasonable and consistent program of study is prepared by the student and his advisory committee. This committee consists of two or more members from the faculty of the Division of Physics and Engineering Science, one of whom is the thesis supervisor. The committee is appointed by the Director of the Graduate School upon the recommendation of the Chairman of the Division of Physics and Engineering Science. Entering students who are found to be deficient in any areas of the undergraduate curriculum in Physics may be required to take appropriate courses in that curriculum.

Language Requirements—The student must demonstrate his ability to read technical German or Russian.

Thesis Examination—Each candidate for the Master of Science degree in this department, upon completion of his thesis, must present himself for an oral examination in the field of his thesis to an examination committee appointed by the Director of the Graduate School and consisting of his advisory committee and any additional faculty members desired by the Director. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the Director of the Graduate School at least one month prior to the close of the last semester. Each student has a right to one re-examination within a period of one year.

Textile Chemistry

The graduate program in Textile Chemistry provides opportunity for advanced study and research in chemistry as applied to textiles and textile auxiliary agents. Formal subjects and research facilities are provided for training in fiber science and in the chemistry of the various processing operations applied to fibers, yarns, and fabrics, including dyeing, finishing, and fiber modifications.

Each student upon entering the curriculum must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry.

The M.S. degree in Textile Chemistry normally requires two years for completion except in those instances where the student possesses previous training in this field sufficiently extensive to meet departmental standards. In the following suggested curriculum those subjects designated by a dagger represent minimum degree requirements.

First Semester

CH	505†	Interpretation of Data	(3-0)3
TC	355*	Chemistry and Physics of Fibers	(3-0)3
TC	401*	Textile Seminar	(2-0)1
TC	411	Chemical Technology of Finishing I	(3-1)3
TE	471	Textile Evaluation	(2-3)3
Total hours			(13-4)13

Second Semester

CH	334	Colloid Chemistry	(3-0)3
CH	512†	Physical Chemistry of Surface-active Agents	(2-0)2
TC	412	Chemical Technology of Finishing II	(3-2)4
TC	422	Chemical Textile Testing	(3-0)3
TC	502†	Theory of Dyeing	(3-4)4
Total hours			(14-6)16

Third Semester

TC	505†	Physical Chemistry of Dyeing	(3-0)3
TC	541†	Graduate Thesis	5
TC	555†	Textile Chemistry Graduate Seminar	(2-0)2
		Elective†	3
Total credit hours			13

Fourth Semester

CH	538†	Rheology	(2-0)2
TC	542†	Graduate Thesis	5
TC	556†	Textile Chemistry Graduate Seminar	(2-0)2
Total credit hours			9

Textile Technology

This graduate program is offered to qualified students in the field of textiles, with primary emphasis upon either the engineering or physical aspects of the field. Ample opportunity is afforded for study and research in the physical and mechanical properties of fibers and textile structures and methods of evaluating them. Work at an advanced level on the structural design of textiles, processing principles, and manufacturing equipment is also available. Applicants should have a B.S. degree in Textile Engineering or Technology, Mechanical Engineering, or Electrical Engineering. Applicants with degrees in other areas, however, are given consideration.

Subject Requirements—The program consists of two years of study. In the first year, basic textile subjects serve as a review for students who have completed their undergraduate studies in textiles elsewhere and as an orientation for students with no textile background. During the first year the students also have an opportunity to prepare for the research projects on which they will base their theses. During the second year, graduate subjects are taken, and the thesis work is completed.

First Semester

MA	383	Statistical Methods	(3-0)3
TE	411	Fundamentals of Textiles—Yarns	(2-2)3
TE	431	Fundamentals of Textiles—Fabrics	(2-2)3
TE	459	Technology of Finishing	(3-1)3
TE	471	Textile Evaluation	(2-3)3
Total hours			(12-8)15

Second Semester

IM	484	Statistical Quality Control	(3-0)3
TE	412	Fundamentals of Textiles—Yarns	(2-2)3
TE	432	Fundamentals of Textiles—Fabrics	(2-2)3
TE	460	Technology of Finishing	(1-2)2
TE	474	Instrumentation for Textiles	(2-2)3
TE	590	Graduate Seminar	(2-0)0
Total hours			(12-8)14

Third Semester

TE	483*	Engineering Design of Textile Structures	(3-0)3
TE	501	Structure and Properties of Fibers	(3-0)3
TE	571	Textile Microscopy	(2-3)3
TE	585	Textile Plants Organization—Yarns	(3-0)3
TE	591	Thesis Seminar	(2-0)1
TE	593	Graduate Thesis	†

†Credits to be arranged.

Fourth Semester

TE	484*	Engineering Design of Textile Structures	(3-0)3
TE	502	Structure and Properties of Fibers	(3-0)3
TE	574	Mechanical Testing of Textiles	(2-3)3
TE	586	Textile Plants Organization—Fabrics	(3-0)3
TE	592	Thesis Seminar	(2-0)1
TE	594	Graduate Thesis	†

†Credits to be arranged.

Thesis Examination—Each candidate for the Master of Science degree in Textile Technology, upon completion of his thesis, must take an oral examination in the field of his thesis. This examination is conducted by a committee appointed by the Director of the Graduate School which must include the thesis supervisor and advisers of the candidate and any additional faculty members desired by the Director. Any faculty members may attend, but only members of the examination committee may conduct the examination. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the semester in which the student expects to be a candidate for the degree. Application to take the examination must be filed by the student with the Director of the Graduate School at least one month prior to the close of the designated semester. If the student fails the oral examination, he has the right to one re-examination within a period of one year. Failure in the re-examination requires the satisfactory completion of a new thesis subject and the accompanying oral examination.

MASTER OF SCIENCE DEGREE REQUIREMENTS

Term of Residence

Applicants with sufficient background in their chosen field of concentration normally require one academic year of residence to complete the requirements for the master's degree. Those with no background require a minimum of two years of residence.

Graduates of other colleges usually need more than one academic year to fulfill the degree requirements, even though they majored as undergraduates in their graduate field of specialization.

All requirements for the master's degree must be completed within five years after the student's entrance. Extension of time beyond this limit may be granted only with joint approval of the student's adviser (or advisory committee), his department head, his division chairman, and the Director of the Graduate School.

Requirements for Graduation

To be recommended for the Master of Science degree a candidate must:

1. Complete a course of study approved by the department in which he has been enrolled. The approved course of study must have

a minimum of 30 credit hours, including thesis. A minimum of 20 credit hours must be spent in listed subjects, and the program should have no fewer than five credit hours of thesis work.

2. Complete a thesis (original research or other investigation, optional with the department) approved by the department in which he has been enrolled, and successfully pass any oral or written examinations on his thesis required by the department at the time his thesis is submitted for final approval. The only grades given for thesis work are S (satisfactory) and U (unsatisfactory). All theses should be submitted in final form to thesis advisers on or before May 15.
3. Maintain residence for at least one academic year.
4. Maintain at least a B— average in all work in formal subjects offered for the degree. The lowest grade acceptable for graduate credit is C. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work, but which are taken during his enrollment as a graduate student, must be passed with a grade of at least C; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.
5. Satisfy all requirements as to tuition and fees.

DOCTOR OF PHILOSOPHY DEGREE PROGRAM

Chemistry

The doctoral program in Chemistry is designed to provide both advanced knowledge and research training in chemistry, particularly in the fields of organic and physical chemistry and polymer science, with emphasis in the field of textiles for those so desiring.

Plan of Program

The doctoral degree normally requires from three to four years of study beyond the bachelor's degree or a minimum of two to three years beyond the master's degree.

The plan of study pursued by each student is dependent on individual requirements and is developed through conference with his advisory committee or, pending its appointment, with his temporary adviser.

All students entering the doctoral program must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry.

Only those students who have taken these examinations previously as candidates for the Master of Science program will be excused.

The initial part of the student's program, normally completed at the end of two years of study, is devoted to formal course work. His first year is usually given to subjects in the major branches of chemistry in preparation for his qualifying (candidacy) examinations. The second year is devoted primarily to advanced subjects in a special field of concentration in preparation for the major examinations.

The second and final part of the program is devoted principally to research leading to the doctoral thesis. However, the student is encouraged to begin research as early as possible in his program of study.

Upon entrance to the doctoral program, each student is assigned an advisory committee. This committee is appointed by the Director of the Graduate School, based upon recommendation by the Chairman of the Division of Chemistry and Applied Chemistry, and consists of at least three members of the faculty. Of these at least two must be from the faculty of the Division of Chemistry and Applied Chemistry. One member of the committee representing the student's major field of interest serves as temporary chairman. After the student has selected his thesis supervisor, the temporary chairman of the advisory committee is replaced by the thesis supervisor, who then serves as permanent chairman.

Examinations

Qualifying Examinations—Three written qualifying examinations are given by the Chemistry Department, each involving one full day. These examinations cover the fields of organic chemistry, physical chemistry, and inorganic-analytical chemistry. Before the student can be admitted to candidacy for the doctorate, he must pass all three examinations.

Qualifying examinations are given in all fields twice each year, in September during or before the week of registration and in June following the final examination period. All three qualifying examinations must be attempted not later than the beginning of the third semester of graduate study in the doctoral program (normally in September of the second year), though any one or all may be attempted earlier. In cases of failure, re-examinations may be taken only during the June period. A second failure in any one of the examinations results in automatic dismissal from the doctoral program. All qualifying examinations must be passed before the beginning of the third year in the program.

The comprehensive examination is in two parts, a written examination lasting one day and covering the field of the major, and an oral examination in defense of a proposition.

The written examination is given once a year in September. It should be taken as soon as possible after completion of the bulk of course work in listed graduate subjects in the field of specialization. However, it must

be taken not later than the beginning of the fourth year of study in the doctoral program. Where it is necessary to carry less than the normal credit load of 12+ per semester, the student must apply for extension beyond this deadline to the chairman of the division through the chairman of his advisory committee.

The proposition represents a thesis in miniature without laboratory work. With the aid and advice of his advisory committee the student selects a subject suitable for investigation, completes a literature survey, outlines the method of approach, and suggests possible results and conclusions. He is then required to defend his proposition by oral examination. The examination is conducted by the student's advisory committee and other faculty members of the department.

Prior to the oral examination and at least one month before the scheduled date of the written comprehensive examination, the student must file with the chairman of his advisory committee three written copies of his proposition, presented in the form generally prescribed for a thesis. The oral defense of the proposition is presented at a time following the written comprehensive examination, and permission to take the oral examination is contingent on first passing the written test.

The request to take both qualifying and comprehensive examinations must be initiated by the student. The request is made to the advisory committee, and the chairman of that committee then submits a written recommendation to the division chairman that the examination be given. The examination schedule is published well in advance of the date set, and the student must file the request with his advisory committee at least one month before the scheduled date. The deadline normally is 5 P.M., May 1, for the June examinations and 5 P.M. on the last day of classes in the second semester for the September examinations.

Language Examinations—A candidate for the doctorate must demonstrate by examination ability to read technical literature in two foreign languages. One foreign language must be German. The second language is generally French or Russian. Proficiency in English is a requirement for foreign students, and the department reserves the right to establish this proficiency by examination if such action is indicated.

Course Offerings and Distribution

As a basis for the candidacy examinations the following core of subjects is recommended for the first-year students in the doctoral program:

CH 423-424*	Advanced Organic Chemistry	(3-0) (3-0)6
CH 431-432*	Advanced Physical Chemistry	(3-0) (3-0)6
CH 443-444*	Advanced Inorganic Chemistry	(3-0) (3-0)6
CH 564	Organic Qualitative Analysis	(1-6)3

If results from the diagnostic examinations indicate adequate background in any of the above subjects, substitution by a more advanced subject in the 500 series is recommended. Full graduate credit is allowed in

the 400 subjects listed above, but credit is not allowed in advanced 400 subjects representing the field of the major, even though these may be recommended. Additional subjects in chemistry or in the field of the minor may be taken in the first year if desired, provided the prerequisites are met.

In the second year, subjects supporting concentration in specific fields are available as follows:

Organic Chemistry

CH 513	Chemical Applications of Spectroscopy and Spectrophotometry	(3-0)3
CH 514	Physicochemical Methods	(2-0)2
CH 521-522	Physical Organic Chemistry	(3-0) (3-0)6
CH 524	Organic Chemistry of Macromolecules	(3-0)3
CH 525	Chemistry of the Carbohydrates	(3-0)3
CH 527-528	Stereochemistry	(2-0) (2-0)4
CH 561-562	Advanced Organic Synthesis	(2-0) (2-0)4
CH 565	Metal-Organic Compounds	(3-0)3
CH 566	Heterocyclic Chemistry	(3-0)3

The core of subjects recommended for majors in organic chemistry includes CH 521-522, CH 527-528, and CH 561-562. Majors in organic chemistry must also meet a requirement in physical chemistry comprising the course sequence CH 539-540 and CH 537.

Physical Chemistry

CH 531-532	Chemical Thermodynamics	(3-0) (3-0)6
CH 533	Statistical Mechanics for Chemists	(3-0)3
CH 534	Quantum Mechanics for Chemists	(3-0)3
CH 535-536	Advanced Topics in Physical Chemistry	(3-0) (3-0)6
CH 537	Chemical Kinetics	(3-0)3
CH 538	Rheology	(2-0)2
CH 539-540	Theoretical Chemistry	(3-0) (3-0)6

Seminar

During each year of residence the student is required to attend and to participate in CH 507-508, Chemistry Seminar, (1-0)(1-0)2.

Majors and Minors

Students may major in organic chemistry or in physical chemistry. The prospective candidate, moreover, is expected to supplement his training in the major field of interest by electing a minor. To avoid overspecialization, this minor is normally selected in a field other than chemistry, although it may include polymer science. The minor may be divided between two fields and should represent a minimum of 12 credits.

Students wishing to minor in polymer science may select subjects from the following offerings:

CH 503-504	Chemistry of High Polymers	(3-0) (3-0)6
CH 523	Physical Chemistry of Macromolecules	(3-0)3
CH 524	Organic Chemistry of Macromolecules	(3-0)3
CH 526	Polymer Physics	(3-0)3

DOCTOR OF PHILOSOPHY DEGREE REQUIREMENTS

Term of Residence

Only work done during the regular academic year from September to June is counted toward residence credit. A minimum of one full academic year of study in residence is required of all candidates. A full year constitutes not less than 36 credit hours of work. Semesters in residence should be consecutive if possible.

All requirements for the doctorate must be completed within seven years after the student's entrance and within four years after admission to candidacy. Extension of time beyond this limit may be granted only with the joint approval of the student's advisory committee, his department head, his division chairman, and the Director of the Graduate School.

Candidacy for the Doctorate

To be admitted to candidacy for the doctorate, a student must:

1. Complete the first year's core of advanced subjects in physical chemistry, organic chemistry, inorganic chemistry, and physico-chemical methods and have a satisfactory record in undergraduate training, graduate seminar, and collateral reading.
2. Pass the qualifying examinations which test his general knowledge. One day each is devoted to an examination in the following areas: organic chemistry, physical chemistry, and combined inorganic-analytical chemistry.
3. Fulfill the language requirements.
4. Secure the approval of his advisory committee and the division chairman.

When these requirements have been fulfilled, the division chairman notifies the Director of the Graduate School in writing and recommends that the student be placed on the list of candidates for the Ph.D. degree. Admission to candidacy in no way guarantees the granting of the degree.

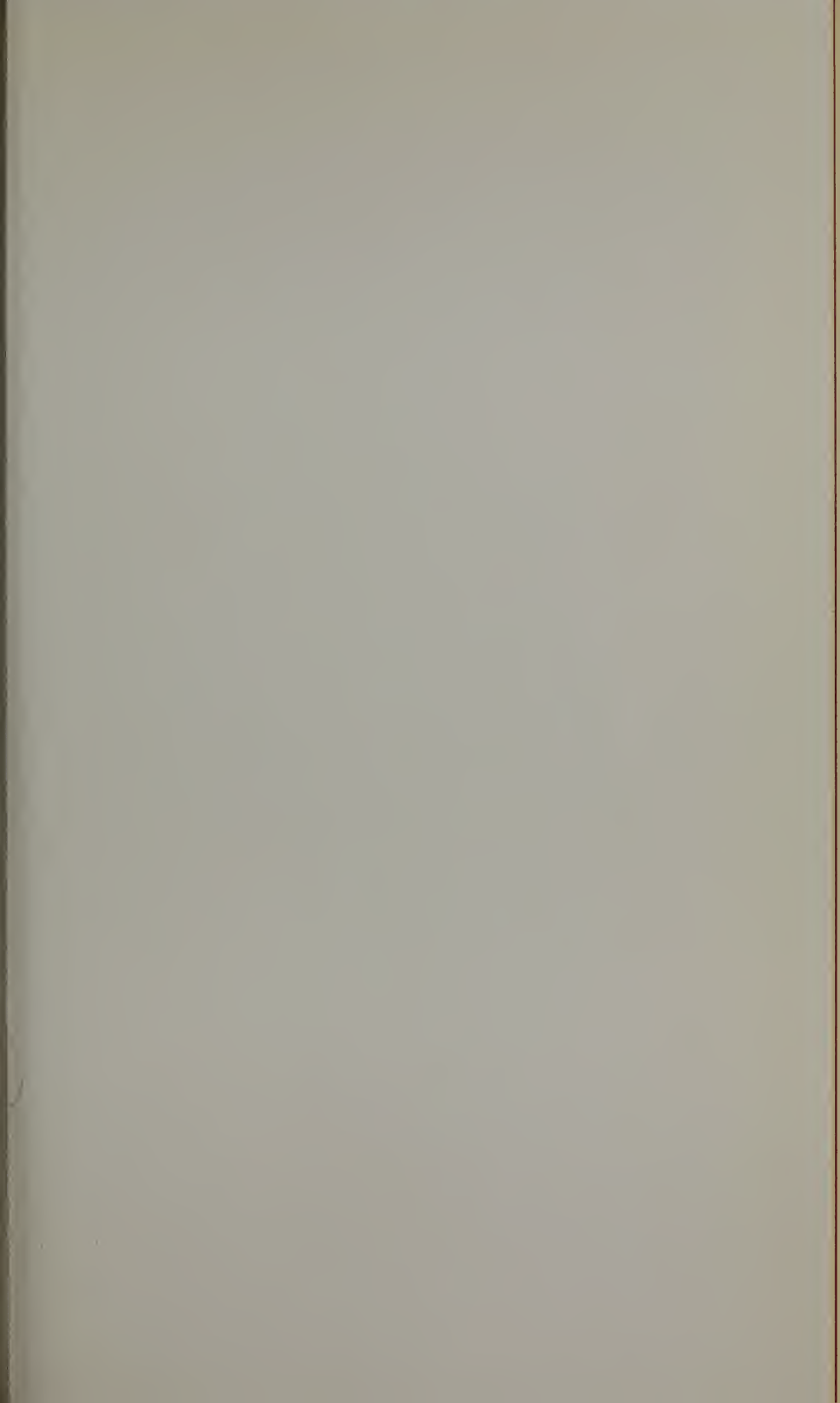
Requirements for Graduation

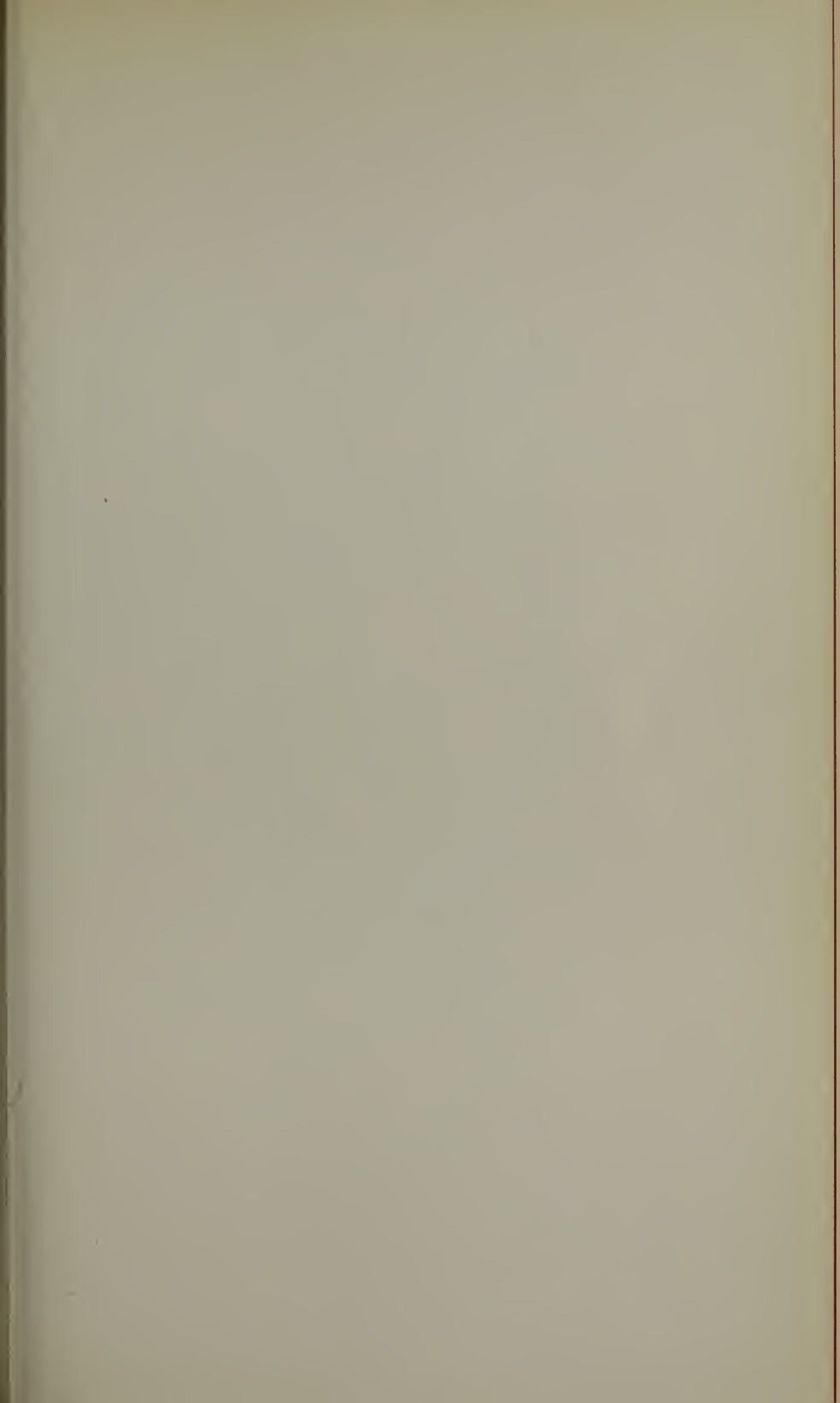
To be recommended for the Doctor of Philosophy degree, a candidate must:

1. Satisfy the residence requirements.
2. Pursue an approved program of study that includes the satisfactory completion of at least 90 credit hours beyond the bachelor's degree, or equivalent. At least half of these credits must be in formal course work exclusive of seminars or thesis.
3. Maintain at least a B — average in all work in formal subjects offered for the degree. The lowest grade acceptable for doctoral credit is C. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work, but which are taken during his enrollment as a graduate student, must be passed with a grade of at least C; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.
4. Demonstrate satisfactory reading ability in German and one other language (preferably French or Russian). Foreign students may under certain circumstances substitute their native tongue for one of these languages. Both language examinations must be passed prior to advancement to candidacy and before extensive work on the thesis is begun.
5. Pass the qualifying examinations for candidacy.
6. Pass the major examinations in the field of concentration. These examinations primarily test the student's knowledge in his special field of concentration and draw heavily on knowledge gained during his second full year of study in that particular area. They are given only when substantially all of the formal course work has been completed, normally at the end of the second full year (fourth semester). The major examination is in two parts. The first part is written and extends over a period of one day. It tests the student's broad knowledge in his specific field. The second part of the major examination is oral and tests the student's aptitude for research and his ability to organize and to develop a research problem. The examination takes the form of the defense of a proposition. The student selects a problem with the approval of his advisory committee.
7. Complete a satisfactory thesis. The doctoral thesis is designed to permit the student to demonstrate his ability to conduct original and independent research work. Results of the thesis investigation

should constitute a definite contribution to knowledge in the field of specialization and should be suitable for publication. The field of the thesis investigation should be selected as soon as possible after admission to the graduate program, and the subject of the thesis must be approved by the advisory committee. As soon as the subject has been selected, the student must make his choice known to the department head, who in turn notifies the Graduate School so that the list of theses in progress may be kept current. The thesis subject must be filed not later than two weeks after the student has been admitted to candidacy. The thesis normally constitutes about half of the total credit requirement and, as a rule, requires three to four semesters of full-time work.

8. Pass a thesis examination. This is an oral defense of the student's thesis before the faculty of the Department of Chemistry.
9. Satisfy all requirements as to tuition and fees.







LOWELL TECHNOLOGICAL INSTITUTE



Register of Courses
1964-1965

DIRECTORY

Further information concerning these subjects may be obtained by writing to the following sources:

admissions, scholarship aid	Dean of Students
official transcripts	Registrar
graduate studies	Director of Graduate School
summer school	Director of Summer School
evening study program	Director of the Evening Division
alumni affairs	Alumni Office
graduate placement	Placement Director
library, industrial responses, membership	Librarian
conferences, special programs, public relations	Coordinator of Special Services
sponsored research	Lowell Technological Institute Research Foundation

LOWELL TECHNOLOGICAL INSTITUTE

Register of Courses

1964-1965



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ACADEMIC CALENDAR

1964-1965

September 8, Tuesday	Freshman Orientation Week begins. Registration of graduate students begins.
September 14, Monday	Registration of sophomores.
September 15, Tuesday	Registration of seniors and juniors.
September 16, Wednesday	Classes begin.
September 22, Tuesday	Last day to register for new classes.
October 12, Monday	Columbus Day. Institute closed.
November 11, Wednesday	Veterans' Day. Institute closed.
November 13, Friday	Last day to drop classes without penalty.
November 25, Wednesday, 12 NOON	Thanksgiving recess begins.
November 30, Monday	Classes resume.
December 18, Friday, 5 P.M.	Christmas recess begins.
January 4, Monday	Classes resume.
January 14, Thursday, 8 A.M.	Freshman examinations begin. (All other classes continue.)
January 15, Friday	Other first-semester examinations begin.
January 21, Thursday	End of first semester.
January 26, Tuesday	Registration of freshmen.
January 28, Thursday	Registration of sophomores and graduate students.
January 29, Friday	Registration of juniors and seniors.
February 1, Monday	Classes begin.
February 5, Friday	Last day to register for new classes.
February 22, Monday	Washington's Birthday. Institute closed.
March 19, Friday, 12 NOON	Spring recess begins.
March 29, Monday	Classes resume.
March 31, Wednesday	Last day to drop classes without penalty.
April 19, Monday	Patriots' Day. Institute closed.
May 14, Friday	Last day for submitting graduate theses.
May 19, Wednesday	Second-semester examinations begin.
June 4, Friday	End of second semester.
June 6, Sunday	Baccalaureate and Commencement.

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Lowell, Massachusetts 01854

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- JOSEPH W. WATERMAN, B.S. (University of Vermont), M.B.A. (Boston University), *Asst. Prof., Social Sciences*
- EARL J. WATT, A.B., A.M. (Harvard University), *Assoc. Prof., Languages and Literature, and Coordinator of Special Services*
- A. EDWIN WELLS, B.T.E. (Lowell Technological Institute), M.Ed. (Boston University), P.E. (Massachusetts), *Prof., Mechanical and Textile Engineering*
- ALBERT T. WOIDZIK, B.S. (Lowell Technological Institute), P.E. (Massachusetts), *Assoc. Prof., Textile Technology*
- FRANCIS T. WORRELL, B.S. (University of Michigan), M.S., Ph.D. (University of Pittsburgh), *Prof., Physics and Mathematics*
- WALDO W. YARNALL, B.S. (University of Vermont), *Director of Athletics*

Professors Emeriti

- HERMANN H. BACHMANN
- HORTON BROWN, B.S.
- WILLIAM G. CHACE, Ph.B., M.S.
- HAROLD C. CHAPIN, A.B., A.M., Ph.D.
- LESTER H. CUSHING, A.B., Ed.M.
- JAMES G. DOW, A.B.
- ELMER E. FICKETT, B.S., Sc.D.
- C. LEONARD GLEN
- MARTIN J. HOELLRICH
- NATHANIEL E. JONES
- JAMES H. KENNEDY, JR., B.T.E., M.S.
- GILBERT R. MERRILL, B.T.E.

ADMINISTRATIVE ASSIGNMENTS

Admissions Office

MAURICE W. HARRISON, B.T.E., *Director of Admissions*
MARY E. PERKINS, *Secretary*

Assistant to the President's Office

KLEONIKE BENTAS, *Secretary*

Buildings and Power

GEORGE F. ABODEELY, LL.B., *Administrator*
RALPH E. FROST, *Chief Engineer*
JOSEPH A. NERNEY, *Maintenance Foreman*

Bursar's Office

WILFRID J. BRODEUR, *Bursar*
IRENE D. BURNS, *Clerk*
GERALD F. CRONIN, *Administrative Assistant*
PATRICIA J. GALLAGHER, *Bookkeeper*
CHARLES F. JOHNSON, *Property Officer*
DIANE M. PESTANA, *Clerk*
FRANK B. RIDGE, *Administrative Assistant*
JOHN L. SAYER, *Bookkeeper*
MARY C. SULLIVAN, *Clerk*
RUSSELL H. WHITE, *Clerk*

Dean of Faculty's Office

THERESA D. LEBLANC, *Secretary*

Dean of Students' Office

BARBARA JEAN MACCARON, *Secretary*

Division of Chemistry and Applied Chemistry

MONA M. DAVIS, *Secretary*
RAY E. MACAUSLAND, *Chemical Storekeeper*

Division of Evening Studies

ANN V. LENIHAN, *Secretary*
CAROLINE C. LANDRY, *Clerk*
LUKE E. MCCARTHY, *Recorder*

Division of General Studies

JOANNE M. POITRAS, *Clerk*

Division of Physics and Engineering Science

JOAN CINQ-MARS, B.S., *Secretary*
ROY M. COWDREY, B.S.
ELEANOR M. MCKENNA, *Secretary*
LEO F. PATENAUDE, *Electronics Equipment Supervisor*

Graduate School Office

ANITA B. LACIE, *Secretary*

Guidance

JOHN J. MACLAUGHLAN, Ph.B., A.M., *Director*

Health Services

ARLENE D. GORDON, R.N.

(Local physicians and specialists as required)

In-Service Training Program

JOHN J. DESMOND, *Administrative Assistant*

MAUREEN FLAHERTY, *Clerk*

Libraries

HOWARD K. MOORE, A.B., A.M., Ph.D., *Director*

JOSEPH V. KOPYCINSKI, B.S., M.S., M.S. in Library Science, *Librarian*

CHARLES F. DONALDSON, *Library Assistant*

RUTH B. FITZGERALD, *Senior Library Assistant*

MARY P. FRASCARELLI, *Library Assistant*

ELEANOR T. LESSARD, *Library Assistant*

VERA BOYD MEEHAN, B.S., *Senior Library Assistant*

ANN V. PENDERGAST, *Library Assistant*

JUNE E. TRAVERSE, *Library Assistant*

Placement Office

MICHAEL J. TAYLOR, B.A., *Director of Placement*

CAROLE A. ASADOOR, *Clerk*

President's Office

HELEN G. FLACK, S.B., *Executive Secretary*

ELIZABETH P. KENNEDY, C.P.S., *Secretary*

Receptionist

LORRAINE I. LEDOUX

Registrar's Office

WALTER M. DROHAN, A.B., A.M., *Registrar*

NORA M. MACBRAYNE, *Secretary*

MABEL M. MURPHY, *Clerk*

CATHERINE P. OUELLETTE, *Clerk*

Special Services

EARL J. WATT, A.B., A.M., *Coordinator of Special Services*

ANITA B. LACIE, *Secretary*

Summer School

ERNEST P. JAMES, B.T.C., M.S., *Director*

GENERAL INFORMATION

History

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry.

In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of leather chemistry, paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, physics, mathematics, nuclear science, nuclear engineering, industrial management, and business administration.

In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to the Lowell Technological Institute. The Institute grants Bachelor of Business Administration, Bachelor of Science, Master of Science, and Doctor of Philosophy degrees.

Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

Accreditation

The Institute is a member of the Senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends full accreditation to the curricula in electrical, mechanical, and textile engineering, and the chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races and religions are represented in the enrollment. Although the majority of its students are men, the Institute is coeducational.

Campus

The Institute is located 25 miles north of Boston in Lowell, Massachusetts, a city of nearly 100,000, long famous as a textile center and more recently noted for its increasingly diversified industries. The 25-acre campus, situated on the Merrimack River, includes eleven main buildings, among them the library, an auditorium-administration building, six classroom-laboratory buildings, two residence halls, and a power plant. A \$4,500,000 nuclear center and a \$2,120,000 physical education building are under way.

Alumni Memorial Library

The library, dedicated to alumni of the Institute who served in World Wars I and II and the Korean conflict, was erected in 1951 by the Alumni Association through contributions from alumni and friends. Besides a book stack capacity of 80,000 volumes, it contains student activity offices and alumni headquarters and houses one of the world's most complete collections of textile books as well as numerous special collections in the fields of paper, leather, and plastics. It also serves as a depository for U. S. government publications and is available to industrial concerns through its Industrial Corporate Membership program.

Equipment

Laboratory equipment used in the instructional and research programs of the Institute is valued at more than \$10,000,000. It includes such varied apparatus as an electron microscope, analog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, paper, plastics, leather, and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Applicants who apply before the first marking period will not be considered until the Admissions Office has received senior grades for this period. The responsibility of having these marks forwarded to Lowell Technological Institute rests with the applicant. Students from other countries are advised to start the application procedure not less than 12 months in advance of the expected date of enrollment.

Correspondence is welcomed prior to their senior year from

students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Director of Admissions.

Applications for admission must be received by the Institute on or before June 1, prior to the September in which the applicant wishes to matriculate.

All admission records, once submitted, become the property of the Institute and cannot be returned.

An applicant who is in need of financial assistance may request an application for a loan under the National Education Defense Act or an application for scholarship aid AFTER he has been accepted for admission to Lowell Technological Institute.

Application Procedure

A candidate for admission should:

1. Complete the first two pages of the admission application form.

2. Attach a certified check or money order in payment of the application deposit of \$10 (see Student Expenses for explanation).

3. Submit the entire application form to the office of his secondary-school principal, with a request that the office fill out pages 3 and 4 and mail the completed application directly to the Director of Admissions.

4. Request transcripts be sent to Lowell Technological Institute from any college, preparatory school, or institution of learning beyond secondary school that he has attended.

5. Make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test which is required of all applicants for admission to the freshman class at the Institute. The applicant must take the Scholastic Aptitude Test during his senior year in secondary school or thereafter. Letters, telephone calls, etc., will not be accepted in place of the official score card.

Applicants for admission who are in the upper 20% of their high-school class scholastically may be admitted by the Chairman of the Committee on Admissions prior to their completion of the C.E.E.B. examinations. This examination, however, must be completed during the senior year and the results forwarded to Lowell Technological Institute before final acceptance is granted.

6. Undergo a complete health examination by his family physician. The physician must return to the Director of Admissions, in duplicate, on forms provided by the Institute, a certificate of good health, indicating the date of the examination. Health

certificates are not sent to the applicant until he has been finally accepted by the Institute.

7. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of his place of residence. The certificate of residence is not sent to the applicant until he has been finally accepted by the Institute or accepted in the summer precollege program.

8. Upon receipt of his letter of admission, submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll.

Students in the Precollege Refresher Program of the LTI Summer Session are not required to make prepayment of tuition. If an applicant plans to attend the Institute, after receiving his final acceptance letter he should instruct his secondary school to send a transcript of his final grades to the Admissions Office after his graduation.

Individual interviews are not required. However, applicants (and parents, when possible) may visit LTI on one of the regularly scheduled High-School-on-Campus days. Personnel from the Admissions Office will be available to answer questions, and guided tours of the campus will be conducted on these days. This year they will be held on January 8, February 23, and April 2, 1965, commencing at 10:30 A.M. in Cumnock Hall. No appointment is necessary.

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must be a graduate of a secondary school approved by the New England Entrance Certificate Board, the Regents of the State of New York, or a board of equal standing.

2. For all courses except Business Administration a candidate must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	1/2 unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the

deficiency in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least 16 units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

3. For admission to the course in Business Administration a candidate must have completed 16 units of approved high-school work (English 4, mathematics 2, American history and social studies 2, laboratory science 1, foreign language 2, electives 5) as well as the Scholastic Aptitude Test. He should also indicate his choice of this program on the top right-hand corner of the formal application form.

In evaluating credits offered for admission, the Institute is guided primarily by the quality of the scholastic record of the applicant and by his promise on grounds of intellect and character. Therefore, an applicant whose preparation has not followed the normal pattern with respect to the accumulation of unit credits should not hesitate to apply for entrance, provided that the quality of his scholarship gives evidence of ability to do college work and provided that he is recommended by his school.

Admission with Advanced Standing

Transfer students must file a formal application for admission to the Institute and must answer "yes" to question 6(b) on page 1 of the application. This must be received prior to April 1 of the year in which the student wishes to matriculate.

Transfer credit is given for courses satisfactorily completed with a grade of C or better which are the equivalent in quality and scope of those given at the Institute. Final decision on transfer credit rests with the appropriate division chairman and the Dean of Students.

Transfer students who have not taken the Scholastic Aptitude Test of the College Entrance Examination Board for matriculation at their previous college may be required to do so. It is the responsibility of the transfer student to ascertain from the Admissions Office the procedure to be followed prior to his acceptance.

Advanced credit will not be given any student after his matriculation.

Students from Other Countries

All foreign applicants for whom English is a second language and who have been in the United States for less than two years

must take an English proficiency test and have the results sent to the Director of Admissions prior to filing a formal application with the Institute. This test has been furnished to American consular officers by the Department of State. Students should arrange to take that Department's English language examination and request that the results be sent to Lowell Technological Institute. When for any reason it is not possible to take the consular examination, the applicant should make arrangements with the Director of Admissions to take tests recommended by Lowell Technological Institute.

The Institute accepts every year foreign applicants in each class in numbers up to 5% of that class. In all other respects, the admission procedure for foreign students is the same as that required of U. S. citizens. They are urged, however, to have the transcript of their secondary-school and/or college records, as well as all other application materials, submitted, *in English, not less than twelve months in advance of the expected date of enrollment*. All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U. S. students.

To facilitate their adjustment to campus life, all freshman male students from other countries are required to live in the Institute's residence halls and are assigned to rooms shared by U. S. students. Students must supply their own towels, sheets, pillows and pillow-cases, and blankets or may subscribe to a laundry service. Bedding, as well as clothing, should be suitable for a climate in which temperatures normally fall well below the freezing point during the winter months.

ADMISSION OF GRADUATES

See the Graduate School section, beginning page 131.

STUDENT REGULATIONS

All male freshmen not living at home are required to live in the residence halls on campus unless they are excused in writing by the Dean of Students.

Students may take their meals wherever they wish, but a cafeteria and a snack bar are available in the residence halls.

Accident insurance is compulsory and included in the activity and insurance fund. Health insurance is also available, on a voluntary basis.

Attendance at classes is compulsory, although a limited number of absences is permitted.

ACADEMIC GRADES

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

A+	4.30 (97-100)	C+	2.30 (77-79)
A	4.00 (93-96)	C	2.00 (73-76)
A—	3.70 (90-92)	C—	1.70 (70-72)
B+	3.30 (87-89)	D+	1.30 (67-69)
B	3.00 (83-86)	D	1.00 (63-66)
B—	2.70 (80-82)	D—	0.70 (60-62)

F 0 (below 60)

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's *semester* rating. The *cumulative* rating for more than one semester is obtained in the same manner as the computation for the rating of a single semester.

The Dean's List is composed of students who have a semester rating of 3.00 or higher, with no current failures.

In order that a student be classified "clear", he must achieve the following minimum *semester* ratings:

first-semester sophomore	1.45	first-semester junior	1.55
second-semester sophomore	1.50	second-semester junior	1.60
first-semester senior	1.65		

A student must achieve the following cumulative ratings:

beginning of sophomore year	1.40
beginning of junior year	1.50
beginning of senior year	1.60

PROBATION AND DISMISSAL

A student is placed on probation when his *semester* rating is below 1.35. A student who fails to achieve the required *cumulative* rating shall be placed on probation. The probationary period covers the entire semester following the issuance of the semester or cumulative rating which placed the student on probation.

If a student receives a semester rating below 0.70, he is automatically dropped from the Institute without benefit of a probationary period.

A student with a semester rating of less than 1.35 for two consecutive semesters is dropped from the Institute for at least one semester.

A student on academic probation will be dropped from the Institute for at least one semester if during his probationary semester he fails to achieve the required semester rating.

REQUIREMENTS FOR GRADUATION

In order to be recommended for the baccalaureate, a student must:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in a major subject.
2. Earn a cumulative rating of 1.70 or above for the entire period at the Institute.
3. Fulfill the residence requirement of one academic year.

GRADUATION HONORS

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of the students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors—graduation with a rating of at least 3.00 but less than 3.30 for the entire period of study at the Institute;

With High Honors—graduation with a rating of 3.30 or higher for the entire period of study at the Institute;

With Highest Honors—graduation as the highest ranking student in the class and with a rating of 3.70 or higher, contingent upon the completion of at least six semesters of work at the Institute.

EXPENSES PER YEAR

Tuition

U. S. citizens who are residents of Massachusetts \$200

U. S. citizens who are residents of states other than
Massachusetts \$300

All others \$550

Residence halls \$600 per room,
divided equally among occupants (2 to 4)

Student activity and insurance fund \$ 49

ROTC deposit \$ 25

Books, supplies, and related miscellaneous expenses (approximate) \$100

There is no set boarding fee, but a cafeteria is available for meals on a cash basis.

UNDERGRADUATE PROGRAMS

Fourteen fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science except the Business Administration program which leads to the Bachelor of Business Administration degree. These fields are:

Business Administration	Nuclear Science
Chemical Engineering	Paper Engineering
Chemistry	Physics
Electrical Engineering	Plastics Technology
Industrial Management	Textile Chemistry
Mechanical Engineering	Textile Engineering
Nuclear Engineering	Textile Technology

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

The Elective System

In all curricula an opportunity is afforded the student to elect subjects in addition to those required for graduation. These electives fall into two categories: technical electives and general electives.

Technical electives give the student a chance to broaden his professional knowledge by taking subjects allied to his main interest or to further his knowledge of a particular phase by taking additional work therein.

General electives are to be selected from the following subjects. At least two electives must be chosen in the social sciences (SS) and two in languages and literature (LL).

EC 201	Economics I	(3-0)3
EC 202	Economics II	(3-0)3
EC 301	Economic Development of the United States	(3-0)3
LL 213	Introduction to English Literature	(3-0)3
LL 214	Introduction to American Literature	(3-0)3

LL 233	Comparative Literature	(3-0)3
LL 234	Shakespeare	(3-0)3
*LL 261-262	Elementary Technical German	(3-0) (3-0)6
*LL 265-266	Elementary Technical Russian	(3-0) (3-0)6
*LL 365-366	Intermediate Literary and Conversational Russian	(3-0) (3-0)6
LL 367-368	Intermediate Literary and Conversational German	(3-0) (3-0)6
LL 436	English Romanticism	(3-0)3
LL 467	Advanced Seminar in Literary German	(3-0)3
LL 471	The Modern American Novel	(3-0)3
LL 472	The Modern British Novel	(3-0)3
LL 473	World Drama	(3-0)3
LL 474	Modern Drama	(3-0)3
LL 482	The American Short Story	(3-0)3
SS 223-224	The United States Since 1865	(2-0) (2-0)4
SS 225 or 226	Europe—1789-1914	(3-0)3
SS 227 or 228	Europe Since 1914	(3-0)3
SS 301	Government of the United States	(3-0)3
SS 302	Conduct and Control of Foreign Policy	(3-0)3
SS 304	Psychology	(3-0)3
SS 305 or 306	Sociology	(3-0)3
SS 371 or 372	American Civilization to 1865	(3-0)3
SS 403	World Politics: Principles, Structures, Cases	(3-0)3
SS 459	World Politics: The Central Problem of War	(3-0)3
SS 460	Foreign Aid and Foreign Policy	(3-0)3
SS 464	World Politics: Problems of International Organization	(3-0)3
SS 471	The United States in World Politics	(3-0)3
SS 472	Defense Policy	(3-0)3
SS 477 or 478	Twentieth-Century Russia	(3-0)3
SS 479 or 480	The Far East Since 1900	(3-0)3
SS 481 or 482	The Greeks and Western Civilization	(3-0)3
SS 483	Political and Social Thought: Ancient Times to Early Modern Times	(3-0)3
SS 484	Political and Social Thought: Early Modern Times to Present	(3-0)3
SS 485 or 486	The Romans and Western Civilization	(3-0)3
SS 487	American Political Thought to 1865	(3-0)3
SS 488	American Political Thought Since 1865	(3-0)3

*These subjects are not accepted for credit, except as an overload, in Chemistry, Chemical Engineering, Electrical Engineering, Mechanical Engineering, Nuclear Engineering, and Textile Engineering.

The Air Force ROTC Program

By vote of the Board of Trustees, all able-bodied nonveteran male citizens enrolled at the Institute must satisfactorily complete two years of Air Force Reserve Officers Training courses (freshman and sophomore years) before receiving a Bachelor of Science degree.*

Cadets who satisfactorily complete the Basic Course (the first two years) may apply for the Advanced Course (the last two years), subject to the approval of the Professor of Air Science.

Uniforms and all equipment and textbooks required for AF ROTC work are supplied by the United States Air Force. Students in the Advanced Course receive approximately \$600 subsistence payment during the two-year program.

Students who successfully complete the Advanced Course are commissioned as second lieutenants in the United States Air Force Reserve. Those who qualify receive further training after commissioning in scientific skills, pilot or navigator training, meteorology, and administration. Outstanding seniors who are designated Distinguished Military Graduates may apply for regular commissions and postgraduate education assignments.

BASIC COURSE

Freshman Year

First Semester

AS 101 Foundations of Aerospace Power I (0-1)0

Second Semester

AS 102 Foundations of Aerospace Power II (2-1)2

Sophomore Year

First Semester

AS 201 World Military Systems I (2-1)2

Second Semester

AS 202 World Military Systems II (0-1)0

ADVANCED COURSE

Junior Year

First Semester

AS 301 The Growth and Development of Aerospace Power I (3-2)3

Second Semester

AS 302 The Growth and Development of Aerospace Power II (3-2)3

Senior Year

First Semester

AS 401 The Professional Officer (3-2)3

Second Semester

AS 402 The Professional Officer (3-2)3

*As of September, 1965, this requirement will be abolished.

A description of these subjects may be found in the section beginning on page 63.

Subjects required in the AFROTC program in the junior and senior years may be substituted for General Electives in all curricula unless otherwise specified.

Summer Camp

Each cadet enrolled in the Advanced Course is required to supplement his training by attending a summer camp of approximately four weeks duration, usually during the summer preceding his senior year. This encampment is held at one of several combat operational air bases where cadets have the opportunity to observe, fly, and live with career personnel. Transportation from the legal residence of the cadet to the camp and return, uniforms, food, lodging, and medical and dental care are provided by the Air Force, and in addition the cadet receives the pay of a basic airman.

Field Trips

Periodically, the Department of Air Science conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

Flight Instruction

The flight instruction program, designed for seniors in the Advanced Course who plan to enter Air Force pilot training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio, and weather. The flying phase consists of 36.5 hours of flight instruction at government expense.

Veterans

Any veteran who qualifies for and completes successfully the Advanced Course is commissioned a second lieutenant in the Air Force Reserve. Under present Air Force regulations, there is no requirement for an active duty tour; however, a veteran AFROTC graduate may apply for active duty as an officer. The Professor of Air Science may waive, in consideration of military service, portions of the basic course which cannot be completed prior to entrance into the Advanced Course.

The Freshman Program

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating adjustment of the new student to his physical, social, and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Business Administration* or Industrial Management† take the following subjects:

First Semester

‡AS 101	Foundations of Aerospace Power I	(0-1)0
CH 101	General Chemistry	(4-2)4
LL 111	English I	(3-0)3
MA 107	Calculus and Analytic Geometry	(4-0)4
ME 101	Engineering Graphics	(1-2)1
PH 103	Physics	(4-1)4
Total hours		(16-6)16

Second Semester

**AS 102	Foundations of Aerospace Power II	(2-1)2
CH 102	General Chemistry	(4-2)4
LL 112	English II	(3-0)3
MA 108	Calculus and Analytic Geometry	(4-0)4
ME 102	Engineering Graphics	(1-2)1
PH 104	Physics	(4-2)4
Total hours		(18-7)18

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. Students taking Air Science are excused from one hour per week. No academic credit is given for the physical education program.

*The freshman program in Business Administration is given on the next page.

†Majors in Industrial Management substitute EC 201, Economics I (3-0)3, for PH 103, and EC 202, Economics II (3-0)3, for PH 104.

‡Required of all able-bodied, nonveteran male citizens. As of September, 1965, this requirement will be abolished.

**Required of all able-bodied, nonveteran male citizens. As of September, 1965, this requirement will be abolished. Other students must take in its place SS 102, Foundations of National Power (2-0)2.

Business Administration

The specific objective of the curriculum in Business Administration is to provide an undergraduate liberal and professional education for young men and women who have the qualifications and the ambition to be administrators and executives.

The curriculum offers an integration of the traditional liberal arts subjects and those professional subjects which provide the basic foundations of management science. The emphasis in this area is not technical but administrative. A core of business subjects—accounting, economics, finance, business law, statistics, marketing, production—is required of the student. In the junior year the student is permitted limited concentration in one of the following fields: accounting*, economics, finance, marketing, or production. This specialization affords the student a deeper penetration in the area he expects to work in after graduation. It is limited, however, in order not to detract from the broad professional goals of the program as a whole.

*Accounting specialization starts in the sophomore year.

FRESHMAN YEAR

First Semester

*AS	101	Foundations of Aerospace Power I	(0-1)0
BA	141	Accounting I	(2-3)3
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	101	Mathematical Analysis I	(3-0)3
		Science Elective†	3

Total credit hours 15

Second Semester

‡AS	102	Foundations of Aerospace Power II	(2-1)2
BA	142	Accounting II	(2-3)3
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	102	Mathematical Analysis II	(3-0)3
		Science Elective†	3

Total credit hours 17

*Required of all able-bodied, nonveteran male citizens. See page 27. As of September, 1965, this requirement will be abolished.

†Physics, chemistry, biology. (Two semesters of one science must be taken.)

‡Required of all able-bodied, nonveteran male citizens. As of September, 1965, this requirement will be abolished. Other students must take in its place SS 102, Foundations of National Power (2-0)2.

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. Students taking Air Science are excused from one hour per week. No academic credit is given for the physical education program.

SOPHOMORE YEAR

First Semester

AS 201	World Military Systems I	(2-1)2
EC 211	Economic Statistics I	(3-0)3
EC 301	Economic Development of the U.S.	(3-0)3
LL 213	Introduction to English Literature	(3-0)3
MA 201	Mathematical Analysis III	(3-0)3
	Behavioral Science Elective*	(3-0)3
Total hours		(17-1)17

Second Semester

AS 202	World Military Systems II	(0-1)0
BA 344	Cost Accounting	(2-2)3
EC 212	Economic Statistics II	(3-0)3
LL 214	Introduction to American Literature	(3-0)3
MA 202	Mathematical Analysis IV	(3-0)3
	Behavioral Science Elective*	(3-0)3
Total hours		(14-3)15

*Sociology, psychology, or accounting. (Accounting must be taken by students majoring in this subject.)

JUNIOR YEAR

First Semester

BA 321	Marketing Principles	(3-0)3
BA 331	Corporation Finance	(3-0)3
BA 361	Business Law	(3-0)3
BA 371	Production Management I	(3-0)3
	Humanities Elective*	(3-0)3
	Business Elective or Air Science†	3
Total credit hours		18

Second Semester

BA 322	Marketing Problems	(3-0)3
BA 332	Money and Banking	(3-0)3
BA 372	Production Management II	(3-0)3
EC 302	Labor Economics	(3-0)3
	Humanities Elective*	(3-0)3
	Business Elective or Air Science†	3
Total credit hours		18

*English, history, social science, or a foreign language. (A two-year commitment is required for language credit.)

†See list of electives at end of curriculum.

SENIOR YEAR

First Semester

BA 401	International Business Operations	(3-0)3
BA 451	Personnel Management	(3-0)3
BA 481	Insurance	(3-0)3
EC 401	Government and Business	(3-0)3
	Business Elective*	(3-0)3
	Humanities Elective or Air Science†	3
Total credit hours		18

Second Semester

BA 452	Industrial Relations	(3-0)3
BA 492	Transportation	(3-0)3
EC 412	Managerial Economics	(3-0)3
	Business Electives*	(6-0)6
	Humanities Elective or Air Science†	3
Total credit hours		18

*Business Electives: accounting, economics, finance, marketing, personnel management, and production management. (A student must have 12 hours in one area in order to receive credit for concentration in that area.)

†Humanities Electives: English, history, social sciences, and foreign languages. (A two-year commitment is required for language credit.)

Chemical Engineering

The Chemical Engineering curriculum is designed to provide the student with both a firm understanding of scientific principles and practical engineering competence. Graduates are qualified to enter industry or to proceed with graduate studies.

A strong background is provided in the sciences in the first two years, with emphasis in the junior and senior years being placed on chemical engineering subjects and on oral and written reports to train the student in clear thinking and in sound presentation of engineering subjects. The unit operations laboratory and the subjects in industrial chemistry and in economic balance in the senior year prepare the student for entrance into the chemical industry, the petroleum industry, or the plastics industry, or for further graduate work.

The stability of the chemical industry coupled with its strong and continual growth provides the graduate with unrivalled opportunities. The broad training of the chemical engineer permits him to enter not only research and development but production, sales, and market development as well and gives him the tools to develop a career which is both challenging and satisfying.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
CH	201	Organic Chemistry	(3-3)4
CHE	201	Introduction to Chemical Engineering	(3-0)3
CHE	203	Introduction to the Chemical Industry	(1-0)1
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4

Total hours (17-6)18

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
CHE	204	Industrial Stoichiometry	(3-0)3
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(4-2)4

Total hours (16-12)19

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
CHE	303	Chemical Engineering I	(3-0)3
EC	201	Economics I	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
ME	341	Thermodynamics	(3-0)3
		General Elective	(3-0)3
			<hr/>
Total hours			(18-3)19

Second Semester

CH	332	Physical Chemistry	(3-3)4
CHE	304	Chemical Engineering II	(3-0)3
CHE	312	Chemical Engineering Thermodynamics	(3-0)3
EC	202	Economics II	(3-0)3
EE	324	Electrical Energy Conversion	(3-2)4
*LL	214	Introduction to American Literature	(3-0)3
			<hr/>
Total hours			(18-5)20

*ROTC students will substitute AS 302

SENIOR YEAR

First Semester

CHE	405	Chemical Engineering III	(3-0)3
CHE	407	Industrial Chemistry I	(3-0)3
CHE	411	Chemical Engineering Laboratory	(0-6)2
MA	383	Statistical Methods	(3-0)3
ME	215	Engineering Mechanics I	(3-0)3
ME	261	Machine Tool Laboratory	(1-2)1
		General Elective	(3-0)3
			<hr/>
Total hours			(16-8)18

Second Semester

CH	334	Colloid Chemistry	(3-0)3
CHE	408	Industrial Chemistry II	(3-0)3
CHE	410	Economic Balance and Plant Design	(3-0)3
CHE	412	Chemical Engineering Laboratory	(0-6)2
ME	216	Engineering Mechanics II	(3-0)3
		General Elective	(3-0)3
			<hr/>
Total hours			(15-6)17

Chemistry

The curriculum in Chemistry is designed to provide both a thorough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. It includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The curriculum includes a minimum of eighteen credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist.

A graduate of the Chemistry curriculum may select any of several avenues in developing his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the Committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

Admission to the sophomore year in the curriculum is contingent upon the student's receiving a minimum average grade of C— in the two semesters of General Chemistry (CH 101-102) in his freshman year.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
			<hr/>
Total hours			(16-12)19
*Alternate: SS 223, The United States Since 1865			(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
CH	202	Organic Chemistry	(3-3)4
CH	206	Qualitative Analysis	(3-6)5
CH	208	Inorganic Chemistry	(2-2)3
MA	206	Differential Equations	
	or		(3-0)3
MA	384	Statistical Methods	
PH	206	Physics	(4-2)4
Total hours			(15-14)19

JUNIOR YEAR

First Semester

CH	321	Organic Chemistry Laboratory II	(0-6)2
CH	331	Physical Chemistry	(3-3)4
EC	201	Economics I	(3-0)3
LL	261	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
Total credit hours			18

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	342	Organic Qualitative Analysis	(1-6)3
EC	202	Economics II	(3-0)3
LL	262	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
Total credit hours			19

SENIOR YEAR

First Semester

CH	411	Advanced Analytical Chemistry	(2-4)3
CH	443	Advanced Inorganic Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Two Technical Electives	6
Total credit hours			18

Second Semester

CH	444	Advanced Inorganic Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Two Technical Electives	6
Total credit hours			15

Seniors are strongly advised to take CH 423-424 (Advanced Organic Chemistry) or CH 431-432 (Advanced Physical Chemistry) as one of the technical electives. Other technical electives include CH 403-404, CH 407-408, and CH 481.

Electrical Engineering

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering with emphasis in electronics.

Students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classroom.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences, with considerable choice of subjects allowed. These subjects form an important part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of nontechnical knowledge in determining the student's ultimate level of responsibility in professional life.

The criteria used for determining which students from the freshman class seeking admission to major in Electrical Engineering are acceptable as sophomores are as follows:

1. A minimum rating of 2.0 for the second semester of the freshman year.
2. No unremoved failures in freshman subjects.
3. A grade of C (not C—) or higher in MA 108 and PH 104.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
EE	201	Introductory Circuit Theory	(3-0)3
EE	205	Basic Electrical Engineering Laboratory	(0-3)1
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	215	Engineering Mechanics I	(3-0)3
PH	253	Introductory Field Theory	(3-0)3
			<hr/>
Total hours			(15-4)16

*Alternate: SS 223 The United States Since 1865

(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
EE	202	Introductory Circuit Theory	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	216	Engineering Mechanics II	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	254	Introductory Field Theory	(3-0)3
		General Elective	(3-0)3
Total hours			<hr/> (16-3)16

JUNIOR YEAR

First Semester

EE	301	Electronic Devices/Models	(3-0)3
EE	303	Electromagnetics	(3-0)3
EE	307	Network Analysis	(3-0)3
EE	309	Electronic Devices Laboratory	(0-3)1
MA	311	Engineering Mathematics	(3-0)3
		General Elective	(3-0)3
Total hours			<hr/> (15-3)16

Second Semester

EE	302	Electronic Devices/Models	(3-0)3
EE	304	Electromagnetics	(3-0)3
EE	308	Network Analysis	(3-0)3
EE	310	Electronic Devices Laboratory	(0-3)1
		General Elective	(3-0)3
		Technical Elective	3 or 4
Total credit hours			<hr/> 16 or 17

Technical Electives

EE	324	Electrical Energy Conversion	(3-2)4
MA	312	Engineering Mathematics	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
PH	206	Physics	(4-2)4
PH	208	Modern Physics	(3-2)4

SENIOR YEAR

Selective Curricula

Normal

General Elective	3 credits
EE Technical Electives (minimum)	8 credits
EE or Non-EE Technical Elective	3 credits
Minimum credit hours per semester	<hr/> 14

Special

General Electives	6 credits
EE Technical Electives (minimum)	5 credits
Non-EE Technical Elective	3 credits
Minimum credit hours per semester	<hr/> 14

Industrial Management

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide the student with a foundation in science and engineering, in the humanities, and in the social sciences. In addition, the various aspects of management—business organization, production, distribution, accounting, and finance—are studied. The student extends his knowledge of mathematics to include statistics. He is also introduced to the newer research methods, including operations research, linear programming, and game theory. A graduate of this program can expect to find employment as a specialist in accounting, procurement, administration, technical sales, or personnel management.

FRESHMAN YEAR

First Semester

*AS	101	Foundations of Aerospace Power I	(0-1)0
CH	101	General Chemistry	(4-2)4
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	107	Calculus and Analytic Geometry	(4-0)4
ME	101	Engineering Graphics	(1-2)1
Total hours			(15-5)15

Second Semester

†AS	102	Foundations of Aerospace Power II	(2-1)2
CH	102	General Chemistry	(4-2)4
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	108	Calculus and Analytic Geometry	(4-0)4
ME	102	Engineering Graphics	(1-2)1
Total hours			(17-5)17

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. Students taking Air Science are excused from one hour per week. No academic credit is given for the physical education program.

*Required of all able-bodied, nonveteran male citizens. See page 27. As of September, 1965, this requirement will be abolished.

†Required of all able-bodied, nonveteran male citizens. As of September, 1965, this requirement will be abolished. Other students must take in its place SS 102, Foundations of National Power (2-0)2.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
BA	141	Accounting I	(2-3)3
BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
ME	263	Metals Processing	(1-2)1
PH	103	Physics	(4-1)4

Total hours (18-7)19

*Alternate: SS 223, The United States Since 1865 (2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
BA	142	Accounting II	(2-3)3
BA	324	Industrial Marketing	(3-0)3
EC	212	Economic Statistics II	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
PH	104	Physics	(4-2)4

Total hours (15-6)16

JUNIOR YEAR

First Semester

BA	331	Corporation Finance	(3-0)3
BA	371	Production Management I	(3-0)3
IM	351	Motion and Time Study	(0-2)1
ME	315	Applied Mechanics	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
SS	303	Psychology	(3-0)3

ONE OF THE FOLLOWING OPTIONS†

AS	301	(A) The Growth and Development of Aerospace Power I	(3-2)3
BA	325	(B) Advertising	(3-0)3
BA	241	(C) Accounting III	(3-0)3
MA	205	(D) Calculus and Analytic Geometry	(4-0)4

Total credit hours 18 or 19

†The specialization sequence selected by the student must be followed through the senior year unless a waiver is granted by the Department Head.

Second Semester

BA	332	Money and Banking	(3-0)3
BA	344	Cost Accounting	(2-2)3
BA	372	Production Management II	(3-0)3
EC	302	Labor Economics	(3-0)3
ME	372	Strength of Materials	(3-0)3

ONE OF THE FOLLOWING

AS	302 (A)	The Growth and Development of Aerospace Power II	(3-2)3
BA	402 (B)	International Business Operations	(3-0)3
BA	242 (C)	Accounting IV	(3-0)3
MA	206 (D)	Differential Equations	(3-0)3

Total credit hours 18

SENIOR YEAR

First Semester

BA	451	Personnel Management	(3-0)3
EC	301	Economic Development of the U.S.	(3-0)3
EE	351	Industrial Electronics	(3-0)3
ME	343	Heat and Power	(3-0)3
		Special Major Elective*	(3-0)3

ONE OF THE FOLLOWING

AS	401 (A)	The Professional Officer	(3-2)3
BA	421 (B)	Procurement	(3-0)3
BA	341 (C)	Accounting V	(3-0)3
PH	205 (D)	Physics	(4-2)4

Total credit hours 18 or 19

*BA 423, 431, 441, 443, 481; EC 303, 401; IM 371, 483, 509; SS 305.

Second Semester

BA	362	Business Law	(3-0)3
EC	402	Government and Business	(3-0)3
EC	412	Managerial Economics	(3-0)3
ME	494	Industrial Instrumentation	(2-0)2
		Special Major Elective*	(3-0)3

ONE OF THE FOLLOWING

AS	402 (A)	The Professional Officer	(3-2)3
BA	426 (B)	Sales Management	(3-0)3
BA	342 (C)	Accounting VI	(3-0)3
PH	206 (D)	Physics	(4-2)4

Total credit hours 17 or 18

*BA 334, 424, 432, 442, 452, 492; EC 304, 414; IM 484, 504, 510; SS 306.

Mechanical Engineering

This course trains the student in the application of the facts and methods of mathematics and science to the design and use of machinery and processes. Principles of design and analysis are stressed in all subjects, and the systems point of view is emphasized.

The student is thoroughly instructed in basic mathematics, physics, and chemistry. There is a unified sequence in applied mechanics which focuses on a course in design given in the senior year. The properties of engineering materials and the principles of thermodynamics, fluid mechanics, and heat transfer are taught, together with a series of subjects in electrical engineering.

In the laboratory the student becomes familiar with design techniques associated with typical energy conversion devices, controls, and instrumentation.

This curriculum is accredited by the Engineers' Council for Professional Development.

Requirements for admission to the sophomore year are a 2.0 cumulative average, no failures or incomplete courses, and a C average or better in freshman mathematics and physics.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total hours			(19-3)19
*Alternate:	SS	223, The United States Since 1865	(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	206	Physics	(4-2)4
Total hours			(16-4½)17

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	263	Metals Processing	(1-2)1
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	375	Materials Science	(3-2)3
		Two General Electives	(6-0)6
			(19-4)19

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
MA	356	Digital Computer Programming	(2-2)2
ME	314	Mechanical Engineering Laboratory I	(0-3)1
ME	318	Applied Mechanics IV	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
		General Elective	(3-0)3
			(17-7)19

SENIOR YEAR

First Semester

ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	443	Heat Transfer	(3-0)3
ME	495	Electromechanical Engineering	(3-2)4
		General Elective	(3-0)3
		Technical Elective	3
			17

Technical Electives

ME	431	Power Plant Systems	(2-3)3
ME	455	Information Processing Systems	(2-2)3
ME	471	Experimental Stress Analysis	(2-2)3

Second Semester

EC	414	Engineering Economy	(3-0)3
ME	416	Mechanical Engineering Laboratory III	(0-3)1
ME	492	Engineering Systems	(2-0)2
ME	496	Electromechanical Engineering	(3-2)3
		General Elective	(3-0)3
		Two Technical Electives	6
			18

Total credit hours

Technical Electives

ME	422	Machine Design	(2-3)3
ME	456	Information Processing Systems	(2-2)3
ME	472	Experimental Stress Analysis	(2-2)3
ME	476	Physical Metallurgy	(3-0)3
ME	528	Kinematic Mechanism Synthesis	(3-0)3
ME	580	Aero- and Astro dynamics	(3-0)3

Nuclear Engineering

The Nuclear Engineering course was the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.0, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total hours			(19-3)19
*Alternate:	SS	223, The United States Since 1865	(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	208	Modern Physics	(3-2)4
Total hours			(15-4½)17

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
NU	301	Nuclear Radiation and Radiological Safety	(3-0)3
PH	363	Introductory Nuclear Physics	(3-0)3
		General Elective	(3-0)3
Total hours			(18-0)18

Second Semester

MA	302	Advanced Calculus	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
ME	476	Physical Metallurgy	(3-0)3
PH	366	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3
			<hr/>
Total hours			(18-0)18

SENIOR YEAR

First Semester

ME	443	Heat Transfer	(3-0)3
NU	401	Nuclear Engineering	(3-0)3
NU	405	Reactor Theory	(3-0)3
NU	451	Nuclear Instrumentation II	(3-0)3
NU	493	Nuclear Laboratory	(0-6)2
		General Elective	(3-0)3
			<hr/>
Total hours			(15-6)17

Second Semester

CH	484	Nuclear Chemistry and Radiochemistry	(3-3)4
NU	402	Nuclear Engineering	(3-0)3
NU	406	Reactor Theory	(3-0)3
NU	494	Nuclear Laboratory	(0-6)2
PH	462	Nuclear Physics	(3-0)3
		General Elective	(3-0)3
			<hr/>
Total hours			(15-9)18

Nuclear Science

The course in Nuclear Science was the first to be offered by a publicly supported institution in New England. The curriculum emphasizes those fundamental subjects in physics and mathematics necessary for a basic education in all sciences and thus prepares the graduate for advanced studies as well as for responsible positions in industry.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.0, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
EE	203	Fundamentals of Electricity	(3-0)3
LL	261	Elementary Technical German	
	or		(3-0)3
LL	265	Elementary Technical Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
		General Elective	(3-0)3
Total hours			(19-3)19
*Alternate:	SS	223, The United States Since 1865	(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
EE	204	Introductory Electronics	(3-1½)4
LL	262	Elementary Technical German	
	or		(3-0)3
LL	266	Elementary Technical Russian	
MA	206	Differential Equations	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	242	Modern Physics	(3-2)4
PH	258	Electrical Measurements	(2-3)3
Total hours			(15-9½)18

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
PH	311	Intermediate Mechanics	(3-0)3
PH	321	Intermediate Thermodynamics	(3-0)3
PH	343		
	or	Atomic and Nuclear Physics	(3-0)3
PH	345		
PH	353	Electromagnetic Theory	(3-0)3
		General Elective	(3-0)3
			<hr/>
Total hours			(18-0)18

Second Semester

MA	302	Advanced Calculus	(3-0)3
PH	312	Intermediate Mechanics	(3-0)3
PH	324	Introduction to Statistical Mechanics	(3-0)3
PH	344		
	or	Atomic and Nuclear Physics	(3-0)3
PH	346		
PH	354	Electromagnetic Theory	(3-0)3
PH	394	Physics Laboratory	(0-3)1
		General Elective	(3-0)3
			<hr/>
Total hours			(18-3)19

SENIOR YEAR

First Semester

MA	433	Matrix Algebra	(3-0)3
NU	301	Nuclear Radiation and Radiological Safety	(3-0)3
NU	451	Nuclear Instrumentation II	(3-0)3
NU	493	Nuclear Laboratory	(0-6)2
		General Elective	(3-0)3
		Technical Elective	3 or 4
			<hr/>
Total credit hours			17 or 18

Technical Electives

MA	543	Partial Differential Equations I	(3-0)3
MA	573	Functions of a Complex Variable	(3-0)3
PH	411	Quantum Theory	(3-0)3
PH	471	Solid-State Physics	(3-0)3
PH	511	Classical Mechanics	(3-0)3
PH	557	Electricity and Magnetism	(3-0)3
PH	565	Nuclear and Electron Spin Resonance Phenomena	(3-3)4

Second Semester

CH	484	Nuclear Chemistry and Radiochemistry	(3-3)4
MA	484	Probabilities	(3-0)3
NU	494	Nuclear Laboratory	(0-6)2
PH	462	Nuclear Physics	(3-0)3
		Two Electives	6 or 7

Total hours	18 or 19
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Technical Electives

MA	526	Modern Algebra	(3-0)3
MA	546	Partial Differential Equations II	(3-0)3
PH	412	Quantum Theory	(3-0)3
PH	472	Solid-State Physics	(3-0)3
PH	512	Classical Mechanics	(3-0)3
PH	524	Low-Temperature Physics	(3-3)4
PH	558	Electricity and Magnetism	(3-0)3

Paper Engineering

The Paper Engineering curriculum is basically the Chemical Engineering course with a major in the technology of pulp and paper manufacture and paper converting. Graduates of this program may go directly into industry or continue with graduate studies in either Paper or Chemical Engineering. The Paper Engineering Department offers an M.S. in Paper Engineering.

The paper industry is the fifth largest industry in the United States, offering employees both stability and excellent opportunities for advancement. The increasing complexity of pulp and paper operations and the growth of paper converting, involving plastics, chemicals, and metals, have created a growing demand for men with sound engineering training and especially for those particularly trained in the paper industry. Graduates of the Paper Engineering course are qualified to enter the paper industry in research and development, production, sales and market development, or management.

The interest of industry in Paper Engineering graduates is evidenced by the generous scholarships available to students enrolled in this program. Five four-year scholarships amounting to \$2,000 over the four-year period are available, and other scholarships are granted based on individual scholastic records.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
CH	201	Organic Chemistry	(3-3)4
CHE	201	Introduction to Chemical Engineering	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PA	201	Introduction to Paper Engineering	(1-0)1
PH	205	Physics	(4-2)4
Total hours			(17-6)18
*Alternate: SS 223, The United States Since 1865			(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
CHE	204	Industrial Stoichiometry	(3-0)3
MA	206	Differential Equations	(3-0)3
PH	206	Physics	(4-2)4
Total hours			(16-12)19

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
CHE	303	Chemical Engineering I	(3-0)3
EC	201	Economics I	(3-0)3
*LL	213	Introduction to English Literature	(3-0)3
PA	301	Pulp Systems	(3-0)3
PA	303	Pulp Systems Laboratory	(2-6)4
			<hr/>
Total hours			(17-9)20

*ROTC students will substitute AS 301.

Second Semester

CH	332	Physical Chemistry	(3-3)4
CHE	304	Chemical Engineering II	(3-0)3
*EC	202	Economics II	(3-0)3
EE	324	Electrical Energy Conversion	(3-2)4
PA	302	Paper Systems	(3-0)3
PA	304	Paper Systems Laboratory	(1-6)3
			<hr/>
Total hours			(16-11)20

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

CHE	405	Chemical Engineering III	(3-0)3
CHE	411	Chemical Engineering Laboratory	(0-6)2
ME	215	Engineering Mechanics I	(3-0)3
ME	341	Thermodynamics	(3-0)3
PA	403	Converting Processes	(3-0)3
PA	405	Converting Processes Laboratory	(0-6)2
		General Elective	(3-0)3
			<hr/>
Total hours			(15-12)19

Second Semester

CH	334	Colloid Chemistry	(3-0)3
CHE	312	Chemical Engineering Thermodynamics	(3-0)3
CHE	412	Chemical Engineering Laboratory	(0-6)2
ME	216	Engineering Mechanics II	(3-0)3
PA	414	Paper Research Problems	(1-6)3
		General Elective	(3-0)3
			<hr/>
Total hours			(13-12)17

Physics

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.0, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
EE	203	Fundamentals of Electricity	(3-0)3
LL	261	Elementary Technical German	
	or		(3-0)3
LL	265	Elementary Technical Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
		General Elective	(3-0)3
			<hr/>
Total hours			(19-3)19
*Alternate: SS 223, The United States Since 1865			(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
EE	204	Introductory Electronics	(3-1½)4
LL	262	Elementary Technical German	
	or		(3-0)3
LL	266	Elementary Technical Russian	
MA	206	Differential Equations	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	242	Modern Physics	(4-2)4
PH	258	Electrical Measurements	(2-3)3
			<hr/>
Total hours			(16-9½)18

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
PH	311	Intermediate Mechanics	(3-0)3
PH	321	Intermediate Thermodynamics	(3-0)3
PH	343		
	or	Atomic and Nuclear Physics	(3-0)3
PH	345		
PH	353	Electromagnetic Theory	(3-0)3
		General Elective	(3-0)3
			<hr/>
Total hours			(18-0)18

Second Semester

MA	302	Advanced Calculus	(3-0)3
PH	312	Intermediate Mechanics	(3-0)3
PH	324	Introduction to Statistical Mechanics	(3-0)3
PH	344		
	or	Atomic and Nuclear Physics	(3-0)3
PH	346		
PH	354	Electromagnetic Theory	(3-0)3
PH	394	Physics Laboratory	(0-3)1
		General Elective	(3-0)3
			<hr/>
Total hours			(18-3)19

SENIOR YEAR

First Semester

MA	433	Matrix Algebra	(3-0)3
PH	411	Quantum Theory	(3-0)3
PH	493	Advanced Laboratory	(1-3)2
		Solid-State Physics Elective	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
			<hr/>
Total credit hours			17

Second Semester

PH	412	Quantum Theory	(3-0)3
PH	494	Advanced Laboratory	(1-3)2
		Mathematics Elective	(3-0)3
		Solid-State Physics Elective	(3-0)3
		Two Electives	6
			<hr/>
Total credit hours			17

SENIOR YEAR
(*Experimental Option*)

First Semester

MA	459	Digital Computer Programming and Numerical Analysis	(2-3)3
PH	493	Advanced Laboratory	(1-3)2
		Experimental Elective	3
		General Elective	3
		Two Technical Electives	6
			<hr/>
Total credit hours			17

Second Semester

MA	460	Digital Computer Programming and Numerical Analysis	(2-3)3
PH	494	Advanced Laboratory	(1-3)2
		Experimental Elective	3
		Three Technical Electives	9
			<hr/>
Total credit hours			17

Plastic Technology

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials rather than on the chemical details involved in their synthesis.

However, the close relationship existing between the physical behavior and chemical structure of polymers makes it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics, and quality control augment the basic courses in mathematics, sciences, engineering, and plastics technology to round out a well balanced program.

Students electing Plastics Technology are privileged to become affiliated with the first student chapter of the International Society of Plastics Engineers, an opportunity which affords each student member an early and rewarding professional association.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
CH	201	Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
PL	201	Plastics Technology	(2-0)2
Total hours			(18-6)19
*Alternate: SS 223, The United States Since 1865			(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-6)5
*MA	384	Statistical Methods	(3-0)3
PH	206	Physics	(4-2)4
PL	202	Introduction to Polymeric Materials	(2-0)2
Total hours			(15-12)18

*May substitute MA 206, Differential Equations (3-0)3.

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
*EC	201	Economics I	(3-0)3
EE	323	Electrical Energy Conversion	(3-2)4
ME	261	Machine Tool Laboratory	(1-2)1
ME	313	Mechanics of Solids I	(3-0)3
PL	301	Plastics Technology	(2-2)3
Total hours			(15-9)18

*ROTC students will substitute AS 301.

Second Semester

CH	332	Physical Chemistry	(3-3)4
*EC	202	Economics II	(3-0)3
ME	374	Plastics Mold Design and Construction	(1-2)1
ME	376	Materials Science	(3-2)3
ME	378	Mechanics of Solids II	(3-0)3
PL	302	Plastics Technology	(2-2)3
Total hours			(15-9)17

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4)4
ME	493	Industrial Instrumentation	(2-0)2
PL	401	Plastics Technology	(2-3)3
PL	403	Properties of Polymers	(2-3)3
PL	411	Plastics Seminar	(1-0)1
		Two Electives	(6-0)6
Total hours			(16-10)19

Second Semester

CH	404	Chemistry of High Polymers	(3-4)4
ME	382	Fluid Mechanics	(3-0)3
PL	402	Plastics Technology	(2-3)3
PL	404	Properties of Polymers	(2-3)3
PL	412	Plastics Seminar	(1-0)1
		Elective	(3-0)3
Total hours			(14-10)17

Suggested Electives

CH	423-424	Advanced Organic Chemistry	(3-0) (3-0)6
IM	483 or 484	Statistical Quality Control	(3-0)3
LL	261-262	Elementary Technical German	(3-0) (3-0)6
MA	206	Differential Equations	(3-0)3
PL	406	Plastics Quality Procedures	(3-0)3

Textile Chemistry

The curriculum in Textile Chemistry is designed to provide a sound foundation in the basic principles of chemistry combined with a knowledge of chemical applications in the fiber and textile fields. Graduates are particularly prepared for positions in industrial organizations oriented toward chemicals for textile applications and fiber development and processing.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
TC	201	Introduction to Textiles	(2-0)1
Total hours			(18-12)20
*Alternate: SS 223, The United States Since 1865			(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
CH	202	Organic Chemistry	(3-3)4
CH	206	Qualitative Analysis	(3-6)5
MA	384	Statistical Methods	(3-0)3
PH	206	Physics	(4-2)4
TC	202	Chemistry and Physics of Fibers	(3-0)3
Total hours			(16-12)19

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
EC	201	Economics I	(3-0)3
TC	301	The Purification of Fibers	(2-3)3
TC	311	Chemical Textile Testing	(3-0)3
TE	471	Textile Evaluation	(2-3)3
		General Elective	(3-0)3
Total hours			(16-9)19

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	334	Colloid Chemistry	(3-0)3
CH	342	Organic Qualitative Analysis	(1-6)3
EC	202	Economics II	(3-0)3
		General Elective	(3-0)3
		*Technical Elective	3

Total credit hours 19

SENIOR YEAR

First Semester

CH	411	Advanced Analytical Chemistry	(2-4)3
TC	403	The Principles of Dyeing and Printing	(2-6)4
TC	411	Chemical Technology of Finishing I	(3-1)3
		General Elective	(3-0)3
		*Two Technical Electives	6

Total credit hours 19

Second Semester

TC	404	Theory of Dyeing	(3-4)4
TC	412	Chemical Technology of Finishing II	(3-2)4
		General Elective	(3-0)3
		*Two Technical Electives	6

Total credit hours 17

*MA 206 is recommended as the technical elective in the junior year if graduate study is planned.

Technical electives in the senior year must include six credits selected from CH 423-424, CH 431-432, or CH 443-444.

It is recommended that the remaining credits be taken in CH 403-404.

Textile Engineering

This course is based on a sound training in mathematics and science and their application to the solution of technical problems. The curriculum is similar to and related to that in Mechanical Engineering but includes sufficient subjects in textile science to qualify the student for positions in either production or research in the textile industry.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total hours			(19-3)19
*Alternate:	SS 223,	The United States Since 1865	(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
ME	264	Metals Processing	(1-2)1
TE	212	Fiber Science	(3-1)3
Total hours			(16-5½)17

JUNIOR YEAR

First Semester

MA	355	Digital Computer Programming	(2-2)2
MA	383	Statistical Methods	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
TE	363	Textile Systems I	(3-1)3
		General Elective	(3-0)3
Total hours			(19-3)19

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
ME	314	Mechanical Engineering Laboratory I	(0-3)1
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
TE	364	Textile Systems II	(3-2)3
TE	366	Textile Systems III	(2-1)2
		General Elective	(3-0)3
			<hr/>
Total hours			(17-8)19

SENIOR YEAR

First Semester

ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	443	Heat Transfer	(3-0)3
ME	495	Electromechanical Engineering	(3-2)4
TE	367	Textile Systems IV	(2-1)2
TE	483	Engineering Design of Textile Structures	(3-0)3
		General Elective	(3-0)3
			<hr/>
Total hours			(16-9)19

Second Semester

ME	416	Mechanical Engineering Laboratory III	(0-3)1
TE	472	Textile Evaluation	(2-3)3
TE	482	Application of Scientific Methods to Textile Processes	(3-0)3
TE	484	Engineering Design of Textile Structures	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective (Textile)	3
			<hr/>
Total credit hours			19

Textile Technology

This course of study is designed to equip its students with a well-rounded understanding of the theory and principles relating to the processing of textile materials. At the same time it provides the scientific basis necessary to understand and apply this technological knowledge. Basic purpose of the program is to prepare students to become competent textile technologists for eventual supervisory, administrative, or executive positions within the industry and its allied fields. To achieve this end, a comprehensive course covers the basic theory, principles, and applications of the major phases of textile manufacture utilizing all the common fibers, both natural and man-made, and all fabricating processes.

SOPHOMORE YEAR

First Semester

*AS	201	World Military Systems I	(2-1)2
EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
Total hours			(19-3)19
*Alternate: SS 223, The United States Since 1865			(2-0)2

Second Semester

AS	202	World Military Systems II	(0-1)0
EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
ME	262	Machine Tool Laboratory	(1-2)1
TE	212	Fiber Science	(3-1)3
Total hours			(16-5½)17

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
ME	381	Fluid Mechanics	(3-0)3
TE	363	Textile Systems I	(3-1)3
		General Elective	(3-0)3
			<hr/>
Total hours			(17-1)17

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
MA	356	Digital Computer Programming	(2-2)2
ME	342	Thermodynamics	(3-0)3
TE	322	Yarn Technology	(2-2)3
TE	364	Textile Systems II	(3-2)3
		Two General Electives	(6-0)6
			<hr/>
Total hours			(19-8)21

SENIOR YEAR

First Semester

IM	483	Statistical Quality Control	(3-0)3
ME	421	Machine Design	(2-3)3
TE	435	Fabric Technology	(3-2)4
TE	459	Technology of Finishing	(3-1)3
TE	483	Engineering Design of Textile Structures	(3-0)3
		General Elective	(3-0)3
			<hr/>
Total hours			(17-6)19

Second Semester

ME	444	Heat Transfer	(3-0)3
TE	460	Technology of Finishing	(1-2)2
TE	472	Textile Evaluation	(2-3)3
TE	474	Instrumentation for Textiles	(2-2)3
TE	484	Engineering Design of Textile Structures	(3-0)3
		Technical Elective (Textile)	3
			<hr/>
Total credit hours			17

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS	Air Science	ME	Mechanical
BA	Business Administration		Engineering
BI	Biology	NU	Nuclear Science
CH	Chemistry		and Engineering
CHE	Chemical Engineering	PA	Paper
EC	Economics	PH	Physics
EE	Electrical Engineering	PL	Plastics
IM	Industrial Management	SS	Social Sciences
LL	Languages and Literature	TC	Textile Chemistry
MA	Mathematics	TE	Textiles

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are restricted to graduate students. An asterisk following the subject number, e.g., PH 411-412*, indicates a subject which, although it is primarily for undergraduates, may ordinarily be taken for full graduate credit.

Odd numbers designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Hyphenated numbers indicate subjects continuing throughout the year.

Prerequisites are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

Air Science

AS 101-102 Foundations of Aerospace Power I and II (0-1) (2-1)2

An introductory examination of the factors of aerospace power, major ideological conflicts, requirements for military forces in being, responsibilities of citizenship, development and traditions of the military profession, role and attributes of the professional officer in American democracy, organization of the armed forces as factors in the preservation of national security, and the United States Air Force as a major factor in the security of the free world.

AS 201-202 (OE 200) World Military Systems I and II (2-1) (0-1)2

A comparative study of world military forces to include Free World land and naval forces, Free World air forces, communist military systems, and trends in the development and employment of military power.

AS 301-302 (OE 300) The Growth and Development of Aerospace Power I and II (3-2) (3-2)6

An advanced study of communication skills, the nature of war, the history of airpower, the United States Air Force, astronautics and space operations, and the future development of aerospace power. In addition to the three class hours per week cadets have one hour per week of supervised research in the Institute or detachment library preparing briefings and written reports assigned in class. Cadets also take one hour of leadership laboratory per week.

AS 401-402 (OE 400) The Professional Officer I and II (3-2) (3-2)6

A study of professionalism, leadership, and management. Includes the meaning of professionalism, professional responsibilities, the military justice system; leadership theory; functions and practices; management principles and functions; problem solving; and management tools, practices, and controls.

Business Administration

BA 141-142 Accounting I and II (2-3) (2-3)6

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

BA 241-242 Accounting III and IV (3-0) (3-0)6
[BA 142]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

BA 321 Marketing Principles (3-0) (3-0)6
[EC 202]

Analysis of modern methods of marketing and merchandising as they are related to consumer, producer, and middleman.

BA 322 Marketing Problems (3-0)3
[BA 321]

[For students majoring in Business Administration]

An analytic approach to marketing strategy in relation to the problems of organization, coordination, and control. Price policies, the government's role in marketing, and physical distribution.

BA 324 Industrial Marketing (3-0)3
[BA 321]

[For students majoring in Industrial Management]

Problems of marketing industrial goods. Distribution channels, price policies, product line planning, and marketing programs.

BA 325 Advertising (3-0)3
[EC 202]

The relation of advertising to modern business organization and its place in marketing and distribution.

BA 331 Corporation Finance (3-0)3
[EC 202]

Financial aspects of the single proprietorship, partnership, and corporation. The financial function, sources of funds, financial statements, capitalization, and legal aspects of the corporation.

BA 332 Money and Banking (3-0)3
[EC 201]

The role of money and monetary policy in the United States. The banking structure, the Federal Reserve System, other financial institutes, and international monetary systems.

BA 334 Investments (3-0)3
[BA 331]

The organization and operation of stock and bond markets, security speculation, brokerage houses, security price behavior, and exchange regulations.

BA 341 or 342 Accounting V and VI (3-0) 3-0)6
[BA 242]

Advanced accounting, comprising the bridge between accounting principles and the actualities of large-volume modern business. The measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

BA 344 Cost Accounting (2-2)3
[BA 142]

Job lot, process, and standard cost systems, including joint and by-product problems, and the managerial uses of cost data.

BA 361 or 362 Business Law (3-0)3

The principles of commercial law, including contracts, agency, sales, partnerships, corporations, negotiable instruments, bailments and carriers, insurance, personal property, real property, suretyship and guarantees, and bankruptcy.

BA 371-372 Production Management I and II (3-0) (3-0)6

The internal organization and productive process of the manufacturer, including the management functions of planning, directing, and administration in relation to production. Plant layout, materials handling, inventory control, quality control, and time and motion study systems.

BA 401 or 402 International Business (3-0)3
Operations

Distinctive features of international commerce, including principles, government policies, practices, procedures, financing, and foreign exchange.

BA 403 or 404 Electronic Data Processing (3-0)3

The role of digital computers in the solution of management problems. The preparation and solution of sample problems on the Institute's IBM 1620 installation.

BA 421 or 422 Procurement (3-0)3
[BA 324]

Purchasing procedure, quality control, inventory control, source selection, forward buying, and speculation, as applied to the industrial enterprise.

BA 423 or 424 Marketing Management (3-0)3
[BA 324]

Problems of marketing, especially from the point of view of the formulation of business policy.

BA 426 Sales Management (3-0)3
[BA 324]

Management of the selling function in its broad aspect. Sales organization, compensation, selection, training, and supervision. Market research, product packaging and development, and distribution policies.

BA 431 or 432 Financial Management (3-0)3
[BA 332]

The finance function in business, funds procurement and their effective utilization, and financial budgets.

BA 441 Auditing (3-0)3
[BA 342]

Duties and responsibilities of the auditor, kinds of audits, programs of audit, and auditor statements and reports.

BA 442 Accounting Systems (3-0)3
[BA 342]

Principles of system design; internal control, division of labor, routing of business papers, and procedural practices; systems modifications; and relationship of theory and practice of accounting to systems.

BA 443 Tax Accounting (3-0)3
[BA 342]

Tax problems of partnerships, corporations, reorganizations, personal holding companies, trusts, gifts, and estates. Problems and interpretations of the internal revenue code and regulations of both the Federal and State agencies.

BA 451 Personnel Management (3-0)3

The techniques of recruiting, selecting, training, and planning of members of the work force, including such matters as employee health and safety, welfare and education, and wage and salary administration.

BA 452 Industrial Relations (3-0)3
[BA 451]

Human interaction and group behavior in organized industrial settings. Interpersonal and intergroup conflict, motivation, and leadership. Case problems.

BA 481 Insurance (3-0)3

Theory of risk, physical and moral hazards, types of insurance carriers, and basic features of each of the principal kinds of insurance.

BA 492 Transportation (3-0)3

Social and economic aspects of transportation problems as revealed by analysis of the nature, history, and problems of transportation agencies of the United States.

BA 501 or 502 Research Seminar (3-0)3
[Permission of Department Head]

Designed to give the better Business Administration student an opportunity under the direction of a faculty member to do research in, and report on, an area of special interest.

Biology

BI 101-102

General Biology

(3-0) (3-0)6

A series of lectures and demonstrations designed to introduce the student to principles and phenomena characteristic of living forms.

Chemistry

CH 101-102 General Chemistry (4-2) (4-2)8

Chemical principles and calculations. The chemistry of both metallic and nonmetallic elements and of their compounds and a brief survey of organic chemistry.

CH 103-104 Introductory Chemistry (3-0) (3-0)6
[Not open to chemistry majors]

Selected topics dealing with the important chemical principles, inorganic and organic chemistry, and the major industrial applications.

CH 201-202 Organic Chemistry (3-3) (3-3)8
[CH 102]

The classification, nomenclature, structure, mechanism of reaction, and behavior in bulk of important kinds of organic species. The laboratory work illustrates the experimental techniques which can be used to react, purify, characterize, and identify organic substances.

CH 203 Elementary Organic Chemistry (3-0)3
[CH 102]

This subject enables students not majoring in chemistry to become conversant with the names, structural formulas, properties, and uses of some important industrially available organic substances and with the role which organic chemistry plays in industry and engineering.

CH 205 Qualitative Analysis (3-0)3
[CH 102]

[Primarily for students not majoring in chemistry]

A lecture course dealing with the physical chemistry of aqueous electrolytic solutions. The nature and behavior of solutes and solutions; reaction rate theory and its relation to solubility, proton transfer, and other types of equilibria; and application of the above principles to problems of separation and identification.

CH 206	Qualitative Analysis	(3-6)5
	[CH 102]	

[Primarily for students majoring in chemistry]

Lecture material essentially the same as in CH 205. The laboratory includes experiments illustrating physical-chemical principles as well as some techniques of qualitative analysis, including chromatography, ion exchange, microscopy, and chemical methods of separation.

CH 208	Inorganic Chemistry	(2-2)3
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The chemical behavior, electronic and geometric structures, methods of preparation, reactions, and nomenclature of some of the more common elements and their compounds as well as some of the better-known transition and inner-transition elements. The laboratory deals with the preparation and study of some of the more interesting compounds.

CH 211 or 212	Quantitative Analysis	(3-6)5
	[CH 102]	

The fundamental principles of quantitative analysis. The principles and calculations of gravimetric analysis, including an introduction to mineral separations as well as the analysis of soluble salts; the principles and calculations of volumetric analysis, including neutralization methods, oxidation-reduction methods, and iodometric methods. Offered both semesters.

CH 321	Organic Chemistry Laboratory II	(0-6)2
	[CH 202]	

A continuation of the laboratory portion of CH 202 involving additional laboratory work in synthetic organic chemistry.

CH 331-332	Physical Chemistry	(3-3) (3-3)8
	[CH 102, MA 205, PH 205]	

The formulation and development of the mathematical and mechanical models of theoretical chemistry and their uses in the solution of the practical problems of chemistry and chemical engineering. Topics included are atomic and molecular structure, states of matter, thermodynamics, thermochemistry solutions, electrochemistry, colloids, chemical equilibrium, kinetics, and photochemistry.

CH 334 **Colloid Chemistry** **(3-0)3**
[CH 331 or equivalent]

Theoretical properties of the colloid system. Interfacial phenomena, particle kinetics, electrical properties, and viscosity characteristics are studied. The character of lyophobic and lyophilic sols, gels, and emulsions is developed from the above properties.

CH 342 **Organic Qualitative Analysis** **(1-6)3**
[CH 202; CH 205 or 206]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 402* **History of Chemistry Seminar** **(1-0)1**

A seminar for seniors and graduate students in chemistry. The history of chemistry and the philosophy of science. Assigned readings discussed under the guidance of selected faculty members.

CH 403-404 **Chemistry of High Polymers** **(3-4) (3-4)8**
[CH 202, CH 332]

The physical and organic chemistry of monomers and polymers, including a consideration of non-bonding forces, spectroscopic methods of structure determination, structure and property correlations, fractionation, thermodynamics, and methods of molecular weight determination for polymers in solution; the kinetics of condensation and addition polymerization as applied to polymers and copolymers, mechanism of free radical and ionic polymerization, stereospecific polymers, the chemistry of the more common polymer systems, and preparation of their corresponding monomers.

CH 407-408 **Advanced Studies in Chemistry** **Credits to be arranged**

[Permission of the Chairman of the Chemistry Division and the instructor]

Advanced work in analytical, organic, inorganic, physical, or textile chemistry, including literature survey, laboratory work, and reports.

CH 411 **Advanced Analytical Chemistry** **(2-4)3**
[CH 211 or 212; CH 332]

Advanced analytical techniques based on physical-chemical principles and utilizing instrumental methods wherever applicable. The analytical use of complexes, radiant energy methods, electrochemistry, chromatography, polarography, analytical applications of radioisotopes, and physical methods of separation.

CH 423-424* Advanced Organic Chemistry (3-0) (3-0)6
[CH 202]

Extension of first-year organic chemistry to include additional classes of compounds and special topics. Emphasis is placed on synthetic methods, including the mechanism, scope, and limitations of the important name reactions in the field of synthetic organic chemistry.

CH 431-432* Advanced Physical Chemistry (3-0) (3-0)6
[CH 332]

An extension of introductory physical chemistry for majors in chemistry and related fields, including additional work in chemical thermodynamics, kinetics, and equilibrium as they apply to the various chemical phenomena, with emphasis on the use of chemical literature, methods of treating data, and problem solving.

CH 443-444* Advanced Inorganic Chemistry (3-0) (3-0)6
[CH 332]

A treatment of the structure and reactions of the inorganic elements and their compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics and the theory of the chemical bond, spectroscopy, inorganic stereochemistry, crystal field theory, reactions in nonaqueous solvents, coordination chemistry, and atomic structure, including the structure of the atomic nucleus.

CH 481 Radiochemistry (3-3)4
[CH 332]

Fundamentals of radiochemistry, including radioactivity, atomic nuclei, nuclear reactions, reactors, and radiation detection and measurement with emphasis on the use of radioactive materials in chemical applications. Designed primarily for majors in chemistry and in allied fields.

CH 483 or 484 Nuclear Chemistry (3-3)4
and Radiochemistry
[CH 102]

A review of chemical principles as applied to radiochemistry, including coverage of such topics as radioactivity, nuclear reactors, radiation chemistry, use of tracers in chemical application, and separation and study of fission products.

CH 502 Absorption Spectrophotometry and (2-3)3
 Color Measurement

Theory and application of absorption spectrophotometry to the qualitative and quantitative analyses of chemical substances in both transparent and opaque media in the ultraviolet, visible, and near infrared ranges, including theories of color, vision, and subjective color evaluation.

CH 503-504 **Chemistry of High Polymers** **(3-0) (3-0)6**
[CH 202, CH 332]

An introduction to the physical and organic chemistry of high polymers for graduate students. Similar to CH 403-404 but with additional assigned reading.

CH 505 Interpretation of Data (3-0)3

Mathematical methods of analyzing, plotting, and interpreting experimental data. Lectures and exercises.

CH 507-508 **Chemistry Seminar** **(1-0) (1-0)2**

CH 512 Physical Chemistry of Surface-active Agents (2-0)2

A series of lectures on the physicochemical principles involved in the use of surface-active agents. The surface and bulk properties of the agents are studied and related to the over-all technical properties and uses.

CH 513 Chemical Applications of Spectroscopy (3-0)3
and Spectrophotometry

Theory, limitations, and applications of various types of spectroscopy to chemical research. Visible and ultraviolet, infrared, microwave, nuclear magnetic, and electron paramagnetic resonance spectroscopy. Emphasis is given to the interpretation of spectra, with some importance placed on analytical applications.

CH 514 Physicochemical Methods (2-0)2

An outline of some of the more important physical methods of investigation and their applications to chemical research, including refractometry, polarimetry, microscopy, and chromatography (ion-exchange, adsorption, and gas).

CH 521-522 Physical Organic Chemistry (3-0) (3-0)6
[CH 424, CH 444]

Modern concepts of molecular structure developed and related to the physical and chemical properties of organic compounds. Polarization effects and reaction mechanisms considered in detail.

CH 523 Stereochemistry of Macromolecules (3-0)3
[CH 404, CH 424]

Stereochemical factors affecting the formation and properties of macromolecules.

Offered in alternate years; offered in 1964-65.

CH 524 Organic Chemistry of Macromolecules (3-0)3
[CH 403, CH 424]

An advanced study in polymer science concerned with modern theoretical concepts and including mechanisms of formation and degradation of macromolecules.

Offered in alternate years; offered in 1964-65.

CH 525 Chemistry of the Carbohydrates (3-0)3
[CH 332 or equivalent]

Starting with the chemistry of the simple sugars, this subject leads to a detailed study of the physical chemistry and the organic chemistry of the important polysaccharides, such as cellulose and starch, and of their industrially important derivatives.

CH 527-528 Stereochemistry (3-0) (3-0)6

The fundamental concepts of optical and geometrical isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds.

Offered in alternate years; not offered in 1964-65.

CH 531-532 Chemical Thermodynamics (3-0) (3-0)6
[CH 539-540 or equivalent]

An advanced subject in chemical thermodynamics, with emphasis on the recent mathematical developments in the description of chemical systems and with attention given to current experimental methods of obtaining thermodynamic data. The chemical and physical scientific literature is used extensively.

CH 533 Statistical Mechanics for Chemists (3-0)3
[CH 539-540 or equivalent]

A continuation of the introductory statistical mechanics presented in CH 539-540. Current theories on such topics as configuration of polymer molecules, rubber elasticity, and solution structure, as well as principles of classical statistical mechanics.

CH 534 Quantum Mechanics for Chemists (3-0)3
[CH 539-540 or equivalent]

A continuation of the introduction to quantum mechanics in CH 539-540. Current theories on such topics as quantum mechanical treatment of crystalline solids, imperfect gases and liquids, and electromagnetic susceptibilities.

CH 535-536 **Advanced Topics in** **(3-0) (3-0)6**
Physical Chemistry

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 537 **Chemical Kinetics** **(3-0)3**

The theoretical and empirical treatment of chemical kinetic data of both organic and inorganic chemistry as well as the methods of obtaining these data. The determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanisms, complex reactions, and absolute rate theory.

CH 538 **Rheology** **(2-0)2**

The general principles of the deformation and flow of matter under stresses studied qualitatively and quantitatively. Hookean and non-Hookean elasticity and Newtonian and non-Newtonian flow related to the properties of materials, especially in the field of high polymers.

CH 539-540 **Theoretical Chemistry** **(3-0) (3-0)6**
[CH 431-432 or equivalent]

The formal aspects of quantum mechanics, thermodynamics, and statistical mechanics providing a conceptual and mathematical background for interpreting the behavior of chemical systems.

CH 541-542 **Graduate Thesis** **Credits to be arranged**

An independent investigation of a problem by the student in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

CH 551 **Physical Chemistry of Macromolecules** **(3-0)3**
[CH 404, CH 432]

An advanced treatment of the physical chemistry of macromolecules, including methods available for molecular structure determination. Consideration of the thermodynamic and statistical approaches to the theory of high-polymer solutions, with particular emphasis on molecular weight dependencies and a study of the kinetics of polymerization and depolymerization.

CH 552 **Polymer Physics** **(3-0)3**

A general treatment of the physical behavior of high-polymer systems. Lectures cover microscopic structure, including the structure of polymer molecules, intermolecular forces, first- and

second-order transitions and macroscopic behavior including rheology and mechanical behavior, the kinetic theory of rubber elasticity, electrical, optical, and thermal properties. Comparisons are made with other classes of materials from time to time to emphasize the unique properties of high polymers.

CH 561-562 Advanced Organic Synthesis (2-0) (2-0)4
[CH 423-424 or equivalent]

The application of known organic reactions to the synthesis of chemical species in such fields as the terpenes, steroids, alkaloids, antibiotics, and selected heterocyclic derivatives.

Offered in alternate years; offered in 1964-65.

CH 564 Organic Qualitative Analysis (1-6)3

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565 Metal-Organic Compounds (3-0)3

The chemistry of the important classes of metal-organic compounds, including bis-arene derivatives, as well as the organo-silicon, organo-boron, and organo-phosphorus classes.

Offered in alternate years; not offered in 1964-65.

CH 566 Heterocyclic Chemistry (3-0)3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years; not offered in 1964-65.

Chemical Engineering

CHE 201 Introduction to Chemical Engineering (3-0)3
[CH 102]

Reaction rate, equilibria, and related topics, followed by a detailed investigation of a segment of the chemical industry. Library research on selected topics, with oral and written reports.

CHE 203 Introduction to the Chemical Industry (1-0)1

General discussion of the chemical industry and the part played by the science and engineering disciplines in chemical engineering.

CHE 204 Industrial Stoichiometry (3-0)3
[CH 205 or CHE 201; CH 212 taken concurrently]

Material balances and energy balances, including phase separation and thermochemistry, and their application to chemical engineering processes.

CHE 303 Chemical Engineering I (3-0)3
[CHE 204, MA 205]

The unit operations of fluid flow, mixing, materials handling, size reduction and separation, and filtration.

CHE 304 Chemical Engineering II (3-0)3
[CHE 303]

The unit operations of heat transfer, evaporation, and mass transfer.

CHE 312 Chemical Engineering Thermodynamics (3-0)3
[ME 341]

Application of the first and second laws to chemical engineering problems. Heats of reaction and enthalpy changes as a function of temperature, fugacity and activity, state properties, homogeneous and heterogeneous equilibria, and electrochemical effects.

CHE 405 Chemical Engineering III (3-0)3
[CHE 304]

The unit operations of gas absorption, distillation and extraction, leaching and crystallization, air-water contact operations, and drying.

CHE 407 Industrial Chemistry I (3-0)3
[CHE 204, CH 331, CH 332; CHE 405 taken concurrently]

A quantitative and qualitative study of selected chemical engineering processes and the analysis of material and heat balances, equilibria, rates of reaction, flow sheets, and economic factors.

CHE 408 Industrial Chemistry II (3-0)3
[CHE 407]

The fertilizer, plastics, and petroleum industries; organic chemicals manufacture; and the manufacture of ferrous and non-ferrous metals.

CHE 410 Economic Balance and Plant Design (3-0)3
[CHE 304, CHE 405]

Economic principles applied to the evaluation and optimization of various chemical engineering processes. Several minor projects and a major design problem requiring written reports provide practical application of the various engineering and economic principles.

CHE 411-412 Chemical Engineering Laboratory (0-6) (0-6)4
[CHE 304; CHE 405 taken concurrently]

Experimental studies and projects involving various unit operations. Both individual and group projects. Written and oral reports are required.

Economics

EC 201 Economics I (3-0)3

The foundations and nature of economic principles. National income, money and banking, and monetary and fiscal policy.

EC 202 Economics II (3-0)3 **[EC 201]**

Price and production theories, the distribution of income, comparative economic systems, and a brief survey of economic doctrines.

EC 211-212 Economic Statistics I and II (3-0) (3-0)6

Basic concepts of statistical methods. Topics covered include measures of central tendency, dispersion, frequency distributions, probability distributions, tests of hypotheses, regression analysis, multiple and partial correlation, time series, seasonal variations, index numbers, and analysis of variance.

EC 301 Economic Development of the United States (3-0)3

The background of the present economic system and an intensive study of the influence of science and technology upon our economic development.

EC 302 Labor Economics (3-0)3 **[EC 202]**

The effect of the operation of American capitalism upon the position of labor. Analysis of the rise of union organization and the factors in its growth. Consideration of trends in the labor forces, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 Microeconomic Theory (3-0)3 **[EC 202]**

An advanced examination of price and production theory. The theory of the household and the firm.

EC 304 Macroeconomic Theory (3-0)3 **[EC 202]**

An analysis of Keynesian and post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 401 or 402 Government and Business (3-0)3
[EC 202]

An examination of federal, local, and state controls on business activity, with emphasis on the economic interpretation of the various statutes and court decisions involving business.

EC 403 or 404 International Trade Theory (3-0)3
[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 412 Managerial Economics (3-0)3
[EC 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis, and competitive action.

EC 414 Engineering Economy (3-0)3
[EC 202, or permission of instructor]

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

Electrical Engineering

EE 201-202 Introductory Circuit Theory (3-0) (3-0)6
[MA 108 and PH 104; MA 205 and 206 taken concurrently]

An introduction to the study of the mathematical and physical aspects of electric circuits in which radiation in the form of electromagnetic waves does not play a major role. Kirchhoff's laws, Thevenin's theorem, reciprocity of simple circuits, vector diagrams, vector algebra, sinusoidal steady-state behavior of simple circuits, transients in alternating-current circuits, and coupled circuits.

EE 203 Fundamentals of Electricity (3-0)3
[PH 104; MA 205 taken concurrently]

An introduction to electric circuits for students not majoring in Electrical Engineering but who have a background in basic principles of electricity and magnetism. Direct-current circuits, network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state a.c. circuits, two-terminal networks, and two-terminal-pair networks.

EE 204 Introductory Electronics (3-1½)4
[EE 203, MA 205]

A background subject in electronics for students not majoring in Electrical Engineering, presenting the properties and uses of vacuum tube and semiconductor devices.

EE 205 Basic Electrical Engineering Laboratory (0-3)1
[EE 201 taken concurrently]

Experimental work designed to acquaint the student with electrical instruments and the techniques of electrical measurements and to provide experimental verification of the behavior of passive electrical circuits.

EE 301-302 Electronic Devices/Models (3-0) (3-0)6
[EE 202, MA 206]

Basic concepts, techniques, and methods of analysis of electronic devices, with particular emphasis on the break-point method, piecewise linearization, and active circuit theory. Diode operation, rectification, amplification, and RC/RL wave-shaping. Single-stage, multistage, power, and tuned amplifiers discussed with consideration of gain, band-width, and frequency response.

EE 303-304

Electromagnetics
[EE 202, MA 206]

(3-0) (3-0)6

Electricity and magnetism presented from the field theory point of view, using vector analysis and Maxwell's equations. The static electric field in polarizable and conducting media, static magnetic fields of steady electric currents and ferromagnetic materials, time-changing electric and magnetic fields, magnetic induction, electromagnetic waves and energy flow, and boundary value problems.

EE 307-308

Network Analysis
[EE 202, MA 206]

(3-0) (3-0)6

Continuation of discussions begun in EE 201-202, with emphasis on frequency domain analysis. Mutual inductance, coupled circuits, and transformers; open-circuit and short-circuit natural frequencies and impedance by inspection techniques; complete solution of linear passive networks; power and energy associated with arbitrary excitation functions; Fourier and Laplace transformations and a comparison of network analysis by these methods with the classical differential equation approach; numerical evaluation methods using impulse train techniques; and convolution in the time and frequency domain. Selected topics from the theory of determinants, matrices, linear transformations and quadratic forms and functions of a complex variable emphasizing the basic aspects for analysis problems. A brief introduction to synthesis.

EE 309-310

Electronic Devices Laboratory

(0-3)1

[EE 301-302 and EE 307-308 taken concurrently]

An intermediate laboratory course in which the experiments are designed to stimulate an appreciation for and a realization of the limitations of basic electronic equipment. The experiments are closely coordinated with the allied concurrent courses and provide experimental verification of the principles of electronic devices and circuits.

EE 313 or 314

**Digital Computers—
Applications and Programming**

(2-2)3

The physical principles and instrumentation of digital computers and their application to problems in science and engineering. Programming methods and techniques.

EE 323 or 324

Electrical Energy Conversion
[EE 203, MA 205]

(3-2)4

The generation, control, utilization, and conversion of electrical energy, with special attention given to the construction, characteristics, and operation of direct-current and alternating-current machinery and rectifiers.

EE 351 or 352 Industrial Electronics (3-0)3
[MA 108, PH 104]

[Not open to students majoring in Electrical Engineering, Mechanical Engineering, Physics, or Textile Engineering]

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum- and gaseous-tube characteristics and of circuits containing such tubes for the purpose of rectification, amplification, and oscillation; and industrial photoelectric and time delay relays.

EE 401-402* Feedback Control Systems and (3-0) (3-0)6
Their Components
[EE 202, MA 311]

The various methods of analysis and design of feedback control systems, including the time-domain, frequency-domain, and root-locus approaches. Some coverage of control system components is included.

EE 403-404 Microwave Electronics (3-0) (3-0)6
[EE 304, MA 311]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, generation and focusing of high-current electron beams with electric and magnetic fields, electron optics, velocity modulation, space charge wave propagation and traveling wave interaction with electron beams with application to microwave amplifiers and oscillators, and antennas.

EE 405-406* Communication Electronics (3-0) (3-0)6
[EE 302, MA 311]

Theory and application of thermionic tubes and transistors in amplifiers, oscillators, modulators, and detectors operating class A and in the switching mode. Principles of television and radar communication. Noise in electron devices and circuits.

EE 409-410 Applied Electronics Laboratory (0-4) (0-4)4
[EE 310]

The purpose of this subject is to give the student an experimental familiarity with the nature, application, and performance of various electronic devices. Emphasis is given to methods of electrical measurement and the preparation of good technical reports.

EE 411-412 Logical Design of Digital Computers (3-0) (3-0)6
[EE 302]

Foundations for the complete design of digital computer subsystems, such as arithmetic unit, computer memory, control, and

input-output equipment with emphasis on basic circuitry as well as the logical tools: flip-flops, shift-register, logical gates, and magnetic core memories. Boolean algebra, systems synthesis, coding, and error detection.

EE 425-426* Wave Shaping and Generation (3-0) (3-0)6
[EE 302, MA 311]

Principles and methods of wave shaping and wave generation using active and passive elements. Timing, switching, memory devices, oscillations, and wave shaping. Free use is made of piecewise-linear approximation, the break-point method, and/or the assumed diode state in conjunction with linear network theory. Particular emphasis is given to model representation and its analysis.

EE 427-428 Semiconductor Electronics (3-4) (3-4)10
[EE 302, EE 308, MA 311]

Properties of semiconductor devices; a study of transistors as active network elements, based on two-part theory in matrix presentation; transistor devices analyzed in the periodic steady state and the transient state by transform methods and other methods; and solution by modern methods of problems on linear and non-linear semiconductor devices. Practical experience in transistors, tunnel diodes, and similar devices is gained from an extensive laboratory course.

EE 429-430 Network Synthesis (3-0) (3-0)6
[EE 308, MA 311]

A review of methods of analysis useful in the study of signals, systems, and their response; impedance and admittance properties relating the frequency and time domain aspects of physical circuit behavior; linear passive network theory, emphasizing the synthesis aspects; fundamental works of Foster, Cauer, Brune, Darlington, and Guillemin applied to design of networks having a prescribed driving-point and transfer characteristics; synthesis of coupling networks for prescribed transfer characteristics, including RC, RLC, and minimum-phase and nonminimum-phase types; real part sufficiency and related topics; and Fourier, Laplace, and Hilbert transforms.

EE 431-432 Special Topics in Electronics (3-0) (3-0)6

An analytical consideration of special topics of importance in the field of electronics.

EE 522 **Parametric Amplification** **(3-0)3**
 [EE 302, MA 312]

Treatment of linear and nonlinear systems with varying parameters; solutions to the Mathieu-Hill differential equation; amplification with non-storage and storage-type network elements; the pumped system with applications; and use of semiconductor devices as active network elements.

EE 529-530 **Network Synthesis** **(3-0) (3-0)6**

The formulation of the fundamentals of network theory; establishing realizability conditions and synthesis techniques for various classes of networks and network functions; and methods for realizing one or more networks whenever a function of the given class is prescribed.

EE 531-532 **Seminar in Electronics** **(1-0) (1-0)2**

Discussion by staff members and students of current journal publications and topics of current interest in electronic science, electronic engineering, and related areas of applied physics.

EE 533-534 **Special Problems in Electronics** **Credits to be arranged**

An opportunity for individual study, under the direction of a staff member, of topics in or related to electronic engineering.

EE 535-536 **Graduate Research** **Credits to be arranged**

Supervised research and thesis on some problem in electronic science, electronic engineering, or certain areas of applied physics.

Industrial Management

IM 351 or 352 Motion and Time Study (0-2)1

The application of methods improvement and work measurement techniques. The use of the stop watch, work sampling, and operator charts in terms of application to standard systems such as M.T.M. and Work Factor.

IM 371 or 372 Systems Engineering and (3-0)3
Operations Research

An analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

IM 483 or 484 Statistical Quality Control (3-0)3
[MA 383 or 384 or EC 212]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 504 Management of Computer Operations (3-0)3

The use of digital computers in management problems. Programming of work on the Institute's 1620 computer installation.

IM 509 or 510 Research Seminar (3-0)3
[Permission of Department Head]

An opportunity for the advanced Industrial Management student to do research in an area of special interest under the direction of a member of the department.

Languages and Literature

LL 109-110 English for International Students (3-0) (3-0)6

Training in exposition. Reading and evaluation of selections representative of the major literary types. Designed to meet the English requirement for those for whom English is a second language.

LL 111-112 English I and II (3-0) (3-0)6

Training in the composition of extended exposition. Introduction to logic and to basic research techniques. Analysis and evaluation of collateral readings in the humanities. Introduction to literature.

LL 213 Introduction to English Literature (3-0)3

Interpretation and criticism of selections from the major writers in the chief periods of English literature.

LL 214 Introduction to American Literature (3-0)3

Interpretation and criticism of selections from the major writers in the chief periods of American literature.

LL 233 Comparative Literature (3-0)3

A consideration of at least six world classics as keys to the development of modern culture.

LL 234 Shakespeare (3-0)3

Shakespeare's chief tragedies, comedies, and chronicles. Consideration of Shakespeare's views on the nature of man.

LL 261-262 Elementary Technical German (3-0) (3-0)6

An introduction to the study of the German language to develop a reading knowledge of scientific German. Limited practice in pronunciation and writing. No credit for first semester without second.

LL 265-266 Elementary Technical Russian (3-0) (3-0)6

An introduction to the study of the Russian language to develop a reading knowledge of scientific Russian. Limited practice in pronunciation and writing. No credit for first semester without second.

LL 365-366 **Intermediate Literary and** **(3-0) (3-0)6**
 Conversational Russian
 [LL 266]

Intended to increase reading knowledge and to provide practice in speaking and writing. Russian essays and short stories of moderate difficulty with explanatory notes and vocabulary.

Offered in alternate years; offered in 1964-65.

LL 367-368 **Intermediate Literary and** **(3-0) (3-0)6**
 Conversational German
 [LL 262]

Intended to increase reading knowledge and to provide practice in speaking and writing. German essays and short stories of moderate difficulty with explanatory notes and vocabulary.

LL 436 **English Romanticism** **(3-0)3**

A close study of the central works of Wordsworth, Coleridge, Blake, Byron, Shelley, and Keats, with emphasis on the sensibility peculiar to the poetic and philosophical attitudes of these writers.

LL 465 **Advanced Seminar in Literary Russian** **(3-0)3**
 [LL 366]

Directed study in Russian fiction. Seminar reports on assigned topics are given in Russian every week by each student, orally or in written form as directed.

Offered in alternate years; not offered in 1964-65.

LL 466 **Advanced Seminar in Literary Russian** **(3-0)3**
 [LL 366]

Directed study in Russian nonfiction. Seminar reports on assigned topics are given in Russian every week by each student, orally or in written form as directed.

Offered in alternate years; not offered in 1964-65.

LL 467 **Advanced Seminar in Literary German** **(3-0)3**
 [LL 368]

Directed study in the works of two classical and two modern German writers. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

Offered in alternate years; not offered in 1964-65.

LL 468 Advanced Seminar in Literary German (3-0)3
[LL 368]

Directed study in the works of leading German authors, primarily in the field of nonfiction. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

Offered in alternate years; not offered in 1964-65.

LL 471 The Modern American Novel (3-0)3

A consideration of the outstanding American novelists from 1920 on. Selected works of Faulkner, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3

The development of the novel in English literature from Conrad and Hardy through Huxley and others. Selected novels are read and discussed.

LL 473 World Drama (3-0)3

A survey of the main currents in world drama from early Greek drama to modern European drama. Selected significant plays from the representative periods in the historical development of world drama are read and discussed.

LL 474 Modern Drama (3-0)3

An analysis of major forces in drama from the time of Ibsen to the present. Selected representative plays are read and discussed.

LL 482 The American Short Story (3-0)3

A critical survey of the growth and development of the American short story. Consideration of the works of Poe, Crane, Anderson, and others.

Mathematics

MA 101 Mathematical Analysis I (3-0)3

Number system, linear and fractional equations, exponents and radicals; functions and graphs, trigonometric functions, angular measure, quadratic equations, laws of variation, and functions of a composite angle.

MA 102 Mathematical Analysis II (3-0)3
[MA 101]

Complex numbers, higher-degree equations, inequalities, logarithms, right triangles, oblique triangles, progressions, mathematical induction, binomial theorem, inverse trigonometric functions, permutations, combinations, probability, and determinants.

MA 107 Calculus and Analytic Geometry (4-0)4

Functions and graphs, equations of straight lines, the differentiation and integration of algebraic functions together with applications involving related rates, differentials, maxima and minima, Mean Value Theorem, areas, volumes, lengths of curves, areas of surfaces of revolution, center of mass, the theorems of Pappus, pressure, and work.

MA 108 Calculus and Analytic Geometry (4-0)4
[MA 107]

The differentiation of exponential, logarithmic, and trigonometric functions; integration by parts, integration by partial fractions, integration by trigonometric substitution, and other integral forms; determinants, both second and higher order; properties of roots of higher-degree equations; the conics, translation and rotation of curves, hyperbolic and inverse hyperbolic functions, polar coordinates, parametric equations, differentiation of vectors, and tangential and normal components of velocity and acceleration.

MA 201 Mathematical Analysis III (3-0)3
[MA 102]

Analytical geometry, functions of one variable, differential calculus, integral calculus, functions of several variables, and differential equations.

MA 202 Mathematical Analysis IV (3-0)3
[MA 201]

Set theory, vectors and matrices, probability theory, linear programming, and theory of games.

MA 205 Calculus and Analytic Geometry (4-0)4
[MA 108]

The scalar and vector products of two or more vectors, solid analytic geometry, space curves, curvature, arc length, partial differentiation, directional derivatives, gradient, chain rule, total differential, the method of least squares, maxima and minima of independent variables, line integrals, multiple integration, and three-coordinate systems; series, including Maclaurin, Taylor, and Fourier series, indeterminate forms, and test for convergence; and complex functions including the Argand diagram, DeMoivre's theorem, the Cauchy-Riemann equations, and logarithmic functions.

MA 206 Differential Equations (3-0)3
[MA 205]

The solution of ordinary differential equations and of partial differential equations of the first order and first degree and of forms in certain other orders and other degrees that lend themselves readily to solution. Practical applications to chemistry and engineering.

MA 301-302 Advanced Calculus (3-0) (3-0)6
[MA 206]

Ordinary differential equations, the Laplace transformation, numerical methods of solving differential equations, series solutions of differential equations, boundary value problems and orthogonal functions, vector analysis, topics in higher-dimensional calculus, partial differential equations, partial differential equations of mathematical physics, and complex variable theory.

MA 305 or 306 Theory of Equations (3-0)3
[MA 108]

Mathematical induction, complex numbers, integral and rational roots, solution by radicals, impossibility of certain geometrical constructions, number of real roots, isolation of a root, determinants, and approximate methods of solution.

MA 311	Engineering Mathematics	(3-0)3
	[MA 206]	

[For students majoring in Electrical Engineering]

Vector analysis, complex variable theory, ordinary differential equations, Laplace transformation, and numerical methods of solving differential equations.

MA 312	Engineering Mathematics	(3-0)3
	[MA 311]	

[For students majoring in Electrical Engineering]

Series solutions of differential equations, boundary value problems and orthogonal functions, and partial differential equations with applications from mathematical physics.

MA 355 or 356 Digital Computer Programming (2-2)2
[Permission of instructor]

The programming and operation of the Institute's IBM 1620 digital computer and discussion of larger systems. Selected practice problems related to the specialties of the class are written by the students and tested to completion in the laboratory sessions.

MA 383 or 384	Statistical Methods	(3-0)3
	[MA 108]	

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

MA 401 or 402 Foundations of Mathematics (3-0)3
[MA 205]

The axiomatic method, set theory, transfinite arithmetic, the real number system, and philosophies of mathematics.

MA 403 or 404 Elementary Number Theory (3-0)3
[MA 205]

Properties of integers, including Euclidean algorithm, divisibility, diophantine equations, prime numbers, congruences, residues, and introductory number theory.

MA 405 or 406 **Mathematical Statistics** **(3-0)3**
[MA 205]

Measurements of dispersion, theoretical frequency distributions, tests of goodness of fit and independence, partial and multiple correlations; permutations, combinations, and probability; game theory.

MA 433 or 434* Matrix Algebra (3-0)3
[MA 205]

Algebra of vectors, matrices, and determinants; linear transformations; linear vector spaces; characteristic roots and reduction to diagonal form; quadratic forms; and applications to physics.

MA 459-460* Digital Computer Programming (2-3) (2-3)6
and Numerical Analysis

Basic and advanced programming techniques in the use of high-speed digital computers for the solution of scientific and engineering problems. The preparation and running of sample problems on the Institute's IBM 1620 computer and at least one other larger computer. Numerical analysis techniques include simultaneous equations, least squares data fit, interpolation, numerical solution of differential equations, and other matters.

MA 484* Probabilities (3-0)3
 [MA 302]

Elements of combinatorial analysis, introduction to probabilities, random variables and expectation, law of large numbers, central limit theorem, and elements of mathematical statistics.

MA 515 or 516 **Methods of Applied** **(3-0)3**
 Mathematics

The calculus of variations, integral equations, and applications.

MA 525 or 526 Modern Algebra (3-0)3

Topics in modern algebra, including number theory, equivalence relations, fields, integral domains, ideals, groups, Boolean algebras, sets, and matrices.

MA 533 or 534 Matrix Theory (3-0)3
[MA 433]

The calculus of matrices, including the study of matrix polynomials, series of matrices, matrix functions, and differentiation and integration of matrices; association of matrices with linear differential equations; and applications of matrix methods to engineering.

MA 537-538 Group Theory (3-0) (3-0)6

Elements of set theory; mappings, isomorphisms, and cardinality; semigroups and groups; the theory of finite groups; general representation theory; and applications of group theory to quantum mechanics.

MA 541 or 542	Fourier Series and Boundary Value Problems	(3-0)3
	[MA 206]	

The Fourier series as a tool of analysis, orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics, and boundary value problems.

MA 543 or 544	Partial Differential Equations I	(3-0)3
	[MA 302]	

Ordinary differential equations in more than two variables, geometrical interpretations, partial differential equations of the first and second order, and boundary value problems.

MA 545 or 546	Partial Differential Equations II	(3-0)3
	[MA 543]	

Partial differential equations of the second order, boundary value problems, and a detailed study of Laplace's equation, the wave equation, and the diffusion equation.

MA 553 or 554	Tensor Analysis	(3-0)3
	[MA 433 or 533]	

The tensor concept; covariant and contravariant tensors; the metric tensor, associated tensors, and covariant differentiation; Euclidean and Riemannian manifolds; and applications to geometry and analytical mechanics.

MA 557-558	Computers	(3-2) (3-2)8
	[MA 302]	

The principles of analog and digital computers as a basis for assessing and planning their use in scientific work. Logic design, instrumentation, programming, and numerical analysis. A survey of well-known commercial analog and digital computers. Experience with the computers at the Institute and also a visit to a local computing center having different equipment, during which a course-programmed problem may be run.

MA 563 or 564	Projective Geometry	(3-0)3
	[MA 205]	

An introduction to various non-Euclidean geometrics. Point sets on a line, line pencils, homogeneous coordinates, and the theory of conics and quadrics. Multidimensional geometry, Plucker coordinates, and correlations and collineations in space.

MA 573 or 574 Functions of a Complex Variable (3-0)3
[MA 302]

Complex numbers, point sets, and elementary functions; an introduction to regular analytic functions; classification of singularities; and conformal mapping and applications.

MA 575 or 576 Operational Mathematics (3-0)3
[MA 302]

The Laplace transform and its properties and uses, as in translation of a time function, and in convolution, differentiation, and integration. Elementary applications in the analysis of vibrations, deflections, and electric circuits; problems in partial differential equations; and Fourier transforms.

MA 585-586 Random Processes and Noise Theory (3-0) (3-0)6
[MA 302]

Principles of random noise theory and optimum filtering. Development of the concepts of correlation function and power spectra for the detection of signals in noise. Illustration of the theory in some applications of circuits and computers with emphasis on the formulation of the noise problem, its mathematical solution, and the interpretation of the results for proper design of systems.

MA 591 or 592 Graduate Thesis Credits to be arranged

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

MA 595-596 Mathematics Seminar Credits to be arranged

Discussion of timely topics by visiting scientists, staff, and graduate students. Required of all graduate students.

Mechanical Engineering

ME 101 Engineering Graphics (1-2)1

Communication by graphic representation—orthographic and pictorial. Charts and graphs. Freehand and instrumental multi-view drawing, dimensioning, engineering geometry, pictorial sketching, and projection.

ME 102 Engineering Graphics (1-2)1
[ME 101]

The use of graphics in the solution of problems. Visualization by descriptive geometry, and its exercise in vector geometry and intersections. Graphical calculus, nomography, and empirical equations.

ME 211 Applied Mechanics I (3-0)3
[MA 108, PH 103]

[For students of Mechanical and Textile Engineering]

A development of fundamental ideas of mechanics such as vectors, forces, and moments. A detailed treatment of the free body diagram concept and its application to resultants of force systems, laws of static equilibrium, friction forces, first and second moments, and problems involving various structures and machine parts. First and second moments of scalar quantities are also considered.

ME 214 Applied Mechanics II (3-0)3
[ME 211]

[For students of Mechanical and Textile Engineering]

A continuation of ME 211. The basic laws of kinematics of particles and rigid bodies which involve linear, angular, relative, and absolute motion; Newton's laws and their application to the kinetics of rigid bodies in translation, rotation, and plane motion; and the principles of work, kinetic energy, impulse, and momentum.

ME 215 Engineering Mechanics I (3-0)3
[MA 108, PH 103]

[For students of Electrical and Chemical Engineering and Plastics Technology]

Statics and an introduction to mechanics of materials. Topics include vectors; force systems; moments; friction; moment of iner-

tia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 Engineering Mechanics II (3-0)3
[ME 215]

[For students of Electrical and Chemical Engineering and
Plastics Technology]

Dynamics and mechanics of materials. Topics include beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 261 or 262 Machine Tool Laboratory (1-2)1

The use of basic machine tools such as the lathe, shaper, drill-press, and milling machine, as well as the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, die-casting, welding, gears, and gearing.

ME 263 or 264 Metals Processing (1-2)1

Modern methods of manufacture, including some of the more recent developments such as ultrasonic and chemical milling, explosive forming, and electrolytic grinding. Also the basic instruments used in metrology, such as hardness testers, optical flats, and optical comparators.

ME 311 Applied Mechanics III (3-0)3
[ME 211]

A basic course in strength of materials, including tension, compression, shear, and combined stresses; the Mohr circles for stress and strain; shearing force and bending moment diagrams; stresses and deflections of beams in bending; statically indeterminate problems; and torsion of circular sections and stresses in columns.

ME 313 Mechanics of Solids I (3-0)3
[For students majoring in Plastics Technology]

Statics of rigid bodies, energy principles, kinematics and dynamics of particles and rigid bodies, and introduction to vibrations.

ME 314 Mechanical Engineering Laboratory I (0-3)1
[ME 341]

Experimental work in the various fields of mechanical engineering to gain an appreciation of measurable quantities, analytical approaches, and measuring equipment and techniques. The design, analysis, and synthesis of engineering systems are stressed

throughout. The student is encouraged to devise his own experiments and to obtain and analyze the engineering data required for design.

ME 315 **Applied Mechanics** **(3-0)3**
[MA 108, PH 103]

[For students of Industrial Management and Paper Engineering]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 317 or 318 **Applied Mechanics IV** **(3-0)3**
[ME 214]

The fundamental ideas of statics and dynamics applied to general systems with oscillatory motion. The kinematics of periodic motion; free, undamped, damped, and forced vibrations of systems with a single degree of freedom; and energy methods, systems with multiple degrees of freedom, and special methods for calculation of natural frequencies.

ME 341 **Thermodynamics** **(3-0)3**
[MA 205, PH 205]

Heat and work, the thermodynamic system, the first law of thermodynamics, open and closed systems, and steady-state and unsteady-state systems. The pure substance, the perfect gas, heat capacities, and the equipartition of energy principle. The second law of thermodynamics, the concept of reversibility, heat engines, and the thermodynamic temperature scale. Entropy and its relationship to probability, stability, and information. Availability and free energy.

ME 342 **Thermodynamics** **(3-0)3**
[ME 341]

Applications of the basic principles of thermodynamics; properties of thermodynamic media and their utilization; and combustion processes, flow systems, and power plant cycles.

ME 343 or 344 **Heat and Power** **(3-0)3**
[MA 108, PH 104]

[Not open to students in Electrical, Mechanical,
or Textile Engineering]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 371 or 372 Strength of Materials (3-0)3
[ME 211, ME 315]

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses, analysis of principal stresses, Mohr's circle of stress, and design of members and columns.

ME 374 Plastics Mold Design and Construction (1-2)1
[ME 261 or 262]

Principles of mold design and construction. The machining and finishing operations of plastics, and actual laboratory work in the design and construction of simple molds.

ME 375 or 376 Materials Science (3-2)3
[PH 206]

The dependence of the properties of materials in general on atomic and crystalline structure. X-ray diffraction; equilibrium and rate processes; interatomic attractive forces; diffusion; theory of dislocations; mechanical, electrical, electronic, magnetic, and thermal properties. Standard physical tests and assigned projects are performed in the laboratory.

ME 377 Elements of Materials Science (2-0)2
[Not open to students in Electrical, Mechanical,
or Textile Engineering]

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, cold work, and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 378 Mechanics of Solids II (3-0)3
[For students majoring in Plastics Technology]

Static and dynamic behavior of deformable systems. Stress and strain, torsion, compound stresses, analysis of plane stress and strain, failure theories, statically indeterminate members, stability and buckling, and stresses and deformations in bodies under dynamic loading.

ME 381 or 382 Fluid Mechanics (3-0)3
[MA 205, PH 205]

Definitions and fluid properties; fluid statics; fluid flow concepts and basic equations; reversibility and losses and thermody-

dynamic relations. Dimensional analysis and dynamic similitude: pi-theorem; viscous effects and fluid resistance: Reynolds number, boundary layer, drag on immersed bodies, duct losses, and Moody diagram. Compressible flow: Mach number, shock wave, and frictional and isentropic flow; closed- and open-conduit flow; fluid measurements; water hammer, surge, and cavitation phenomena; and turbomachinery.

ME 415 Mechanical Engineering Laboratory II (0-3)1
[ME 314]

Continuation of ME 314.

ME 416 Mechanical Engineering Laboratory III (0-3)1
[ME 415]

An individual project selected by the student in consultation with the staff. The project must include phases of design, construction, and analysis. Both a formal written report and an oral presentation are required.

ME 421-422 Machine Design (2-3) (2-3)6
[ME 214, ME 311]

The application of the principles of mechanics to the design of typical machine elements, such as shafts, springs, screws, belts, clutches, brakes, bearings, gears, and cams. Theories of failure and methods of establishing working stress levels are considered. The laboratory work consists of comprehensive projects that illustrate the close relationship between analysis and synthesis as they are applied to various machine design problems.

ME 431 Power Plant Systems (2-3)3
[ME 342]

Elements of the design of power plants. Capacities and operating specifications are determined for the equipment of a power plant designed to produce electricity and processing steam for a manufacturing industry. Operating costs are computed based upon current prices of power plant machinery, fuel, labor, and the various necessary supplies.

ME 443 or 444 Heat Transfer (3-0)3
[MA 206; ME 341 and 382]

Modes of heat flow; combined heat transfer mechanisms: analogous electrical network; conduction (steady state and transient): exact and approximate methods of analysis (flux plot, Schmidt plot, finite differences); radiation heat transfer; dimensional analysis,

fluid flow, and boundary layer theory. Reynolds analogy; Nusselt, Prandtl, Biot, Fourier, Graetz, and Grashof numbers; free convection; forced convection; heat transfer to boiling liquids and condensing vapors; and finned surfaces and heat exchangers.

ME 455 or 456 Information Processing Systems (2-2)3
[MA 356 or permission of instructor]

The use of electronic computing systems for the solution of engineering problems, with stress on symbolic programming methods. Student use of the IBM 1620 installation at the Institute is an integral part of the course.

ME 471 or 472 Experimental Stress Analysis (2-2)3
[MA 205, ME 311]

Photoelasticity, including introduction to the theory of elasticity, stress separation by shear difference, arithmetic iteration, oblique incidence, and lateral deformation. Photoelastic coatings; mechanical, optical, and electrical strain gages; brittle lacquer; and analogies.

ME 476 Physical Metallurgy (3-0)3
[MA 206; ME 375 or 376]

A study of metals. Phase diagrams and transformations, the system carbon-iron, electrical and magnetic properties related to structure, thermal and optical properties, elasticity and plasticity (including creep), diffusion, recovery, recrystallization, grain growth, hardening, and heat treatment. Interpretation of microphotographs of polished and etched specimens is stressed, as is the application of the theory to industrial problems involving the failure of metals in service.

ME 491 or 492 Engineering Systems (2-0)2

Application of fundamental engineering principles in the solution of design problems which involve more than one engineering discipline, with emphasis on costs, useful life, reliability, safety, esthetics, miniaturization, maintainability, and interchangeability.

ME 493 or 494 Industrial Instrumentation (2-0)2
[MA 108, PH 104]

[Not open to students majoring in Electrical, Mechanical, or Textile Engineering]

Modern methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level, and fluid flow; response characteristics of mechanical, electric, and

electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; closed-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

ME 495 Electromechanical Engineering (3-2)4
[EE 204, MA 206]

Characteristics of electromechanical transducers and their associated circuitry as employed in the measurement of acceleration, velocity, displacement, stress, strain, thickness, mass, weight, frequency, time, and level of intensity.

ME 496 Electromechanical Engineering (3-2)3
[ME 495]

Servomechanisms and their application to control problems, with emphasis on system analysis by block diagram using transfer function techniques; and use of electrical analogs for analysis and design of mechanical systems.

ME 528 Kinematic Mechanism Synthesis (3-0)3
[ME 214]

Mechanism concepts, symbolic notations, coupler curves, and the Gruebler criterion. Planar linkage synthesis by geometric methods, synthesis of function generators and dwell linkages, and the Euler-Savary equation. Analytic methods of synthesis, Freudenstein's method, kinematics of spatial mechanisms, matrix representation of rotation, and general matrix methods of analysis.

ME 555 or 556 Advanced Computer Problems (3-0)3
[ME 455 or 456; permission of instructor]

An opportunity for students familiar with computers to develop advanced problem application of particular interest to them.

ME 580 Aero- and Astrodynamics (3-0)3
[ME 382, ME 443]

The astronomical unit, the isothermal atmosphere, the troposphere, atmospheric stability, and potential temperature. Kepler's first, second, and third laws. The earth-moon orbital plane, acceleration in a satellite, and scalar equations for flight over a flat earth. The fundamental equations of entry dynamics and general aerodynamic heating analysis, ablation, and shield analysis. Minor-circle flight problems, dynamics of spinning (ballistic missiles), and trajectories. Performance of aircraft with parabolic polars, with arbitrary polars, and at high subsonic, transonic, and supersonic speeds.

Nuclear Science and Engineering

NU 301 or 302 Nuclear Radiation and (3-0)3
Radiological Safety

The basic physics of alpha, beta, and gamma radiation, with emphasis on the more practical considerations. The absorption and scattering of gamma radiation with applications to the design of shielding systems for protection of personnel, and effects of intense radiation on biological systems, structural materials, and chemical reactions.

NU 351 or 352 Nuclear Instrumentation I (2-4)3

Electronic pulse circuitry, including amplifiers, discriminators, counting, coincidence, and pulse height circuits; and the measurement of resolving and response times. Specific experiments in nuclear instrumentation.

NU 401-402 Nuclear Engineering (3-0) (3-0)6
[MA 302; PH 366 or PH 344; NU 405-406 taken concurrently]

The design, construction, and operation of nuclear reactors, with emphasis on quantitative methods. The economic aspects of reactor use are stressed.

NU 403-404 Reactor Instrumentation (2-4) (2-4)6

Elements of servomechanisms; automatic control systems; electrical and electronic theory utilized in the measurement of reactor parameters such as reactivity, danger coefficients, and temperature coefficients; detection of neutron flux with fission, BF_3 , and ionization chambers; analysis and design of power-measuring and period-measuring instruments; and calibration of control rods and general reactor control devices.

NU 405-406 Reactor Theory (3-0) (3-0)6

Review of nuclear physics, interaction of neutrons with matter, nuclear fission, neutron chain reaction systems, neutron flux and interaction rates, diffusion of neutrons, slowing down of neutrons, Fermi theory of the bare thermal reactor, multiregion reactors, the group diffusion method, and reactor kinetics.

NU 451 or 452 Nuclear Instrumentation II
[PH 366]

(3-0)3

The general nature of detection systems; the interaction of ionizing-type radiations with matter; neutron detection; and characteristics of ionization chambers, proportional counters, Geiger-Mueller counters, and scintillation detectors.

NU 493-494

Nuclear Laboratory
[Permission of instructor]

(0-6) (0-6)4

Characteristics of detectors, counting statistics, and calibration and use of instruments; properties of nuclear radiations, indicating ranges of alpha and beta particles, and absorption of gamma rays; neutron activation, radioactive decay, measurement of neutron flux, sigma piles, and gamma spectroscopy. Students may obtain partial credit for work on campus research projects with the approval of the instructor and the research project director.

Paper

PA 201 Introduction to Paper Engineering (1-0)1

A study of major pulp and paper systems to provide sufficient background for more advanced courses, to stimulate an appreciation for the historical development of the industry, and to create an awareness of its current economic opportunities. Available as an elective to students in other major areas of study.

PA 301 Pulp Systems (3-0)3

[CH 211 and PA 201, or permission of instructor]

Lectures and problems concerning the technology of pulp manufacture by the groundwood, sulfite, alkaline, and semichemical processes. Bleaching methods are studied.

PA 302 Paper Systems (3-0)3

[CH 211]

Lectures and problems concerning the technology of paper manufacture. Stock preparation, filling and loading, sizing, coloring, special additives, paper machine operation, and finishing.

PA 303 Pulp Systems Laboratory (2-6)4

[CH 211]

This as well as subsequent laboratory work is designed with a research-type approach to develop the student's ability to plan and analyze the experimental work and to reach logical conclusions from the results. Studies of the principal wood, rag, and wastepaper pulps, with work in wood and pulp microscopy, bleaching, and evaluation of pulps for their papermaking value by physical and chemical testing methods. Detailed written and oral reports are required.

PA 304 Paper Systems Laboratory (1-6)3

[CH 211]

The fundamental processing techniques used in paper manufacture, including investigations of stock preparation, filling and loading, coloring, use of additives, and sheet formation. Detailed written and oral reports are required.

PA 403

Converting Processes

(3-0)3

[PA 302, PA 304]

Lectures and problems concerning the technology of paper and paperboard conversion by mechanical, coating, impregnating, laminating, and printing processes.

PA 405

Converting Processes Laboratory

(0-6)2

[PA 403, usually taken concurrently]

Study of, and practice in, the use of the common techniques employed in the paper and paperboard industry, with emphasis on the colloidal and rheological properties of materials used. Detailed written and oral reports are required.

PA 414

Paper Research Problems

(1-6)3

A research problem connected with some phase of the pulp, paperboard, or converting industry is selected by the student in collaboration with the staff and an advisory committee from the industry. A literature survey is performed, and a preliminary report outlining the problem and the proposed investigation is submitted. Then the investigation is carried out, and a detailed formal report is written.

PA 501-502

Graduate Thesis

**Credits to be
arranged**

Every graduate student is required to prove his ability to carry on independent research by presenting a thesis on an approved subject.

Physics

PH 101-102 **General Physics** **(3-0) (3-0)6**

[For students majoring in Business Administration]

Mechanics, heat, wave motion, sound, light, electricity and magnetism, and modern physics. Lectures and experimental demonstrations.

PH 103 **Physics** **(4-1)4**

[MA 107 taken concurrently]

The principles of mechanics, including physical measurement, composition and resolution of vectors, motion in one dimension and in a plane, particle dynamics, work and energy, conservation of energy, conservation of linear and angular momentum, rotational kinematics and dynamics, statics of rigid bodies, mechanical oscillations, and gravitation.

PH 104 **Physics** **(4-2)4**

[PH 103 or equivalent; MA 108 taken concurrently or previously]

The principles of electricity and magnetism. Charge and matter, electric fields, Gauss's Law, electric potential, capacitance and inductance, and transients in circuits containing inductance, capacitance, and resistance. Magnetic fields, Ampere's Law, Faraday's Law, and electromagnetic oscillation.

PH 205 **Physics** **(4-2)4**

[MA 205 taken concurrently; PH 104]

Temperature; heat and the first law of thermodynamics; kinetic theory of gases, including specific heats; and the second law of thermodynamics. Mechanical oscillators; traveling elastic waves; standing waves; acoustical and optical wave phenomena, such as beats, the Doppler effect, reflection, refraction, interference, and diffraction; polarization; and spectra.

PH 206 **Physics** **(4-2)4**

[PH 205]

Modern physics, including the atomic nature of matter and electricity, variation of mass with velocity, isotopes, the nature of radiant energy, black bodies and the origin of the quantum theory, photoelectricity, spectra, Bohr's theory of the atom, X-ray spectra, waves associated with material particles, the spinning electron,

Pauli's principle, magnetic moment of an atom, the periodic system and quantum numbers, molecular structure, radioactivity, elementary particles, scattering and absorption of particles and photons, transmutation, fission, reactors, fusion, cosmic rays, mesons, hyperons, and relativity.

PH 208 **Modern Physics** (3-2)4
[PH 205]

[For students majoring in Nuclear Engineering]

Charged particle motion in electromagnetic fields, black body radiation, the photoelectric effect, the special theory of relativity, the Bohr atom, quantum mechanics, X-ray scattering and absorption, Compton scattering, and the kinetic theory of gases.

PH 210 **Practical Astronomy** (3-0)3
[MA 205]

Coordinate systems, marine navigation, space navigation, the gravitational potential, Keplerian orbits, and the rendezvous problem in space. The material is developed mainly through the solution of problems.

PH 242 **Modern Physics** (3-2)4
[PH 205]

[For students majoring in Physics or Nuclear Science]

The special theory of relativity, thermal radiation, black body radiation, Planck's theory of black body radiation, discovery of the electron, classical and quantum theories of the photoelectric effect, the Compton effect, Thompson's description of the atom, the Rutherford experiment, atomic spectra, Bohr's theory of the one-electron atom, the Wilson-Sommerfeld quantization rule, Sommerfeld's relativistic theory, DeBroglie's theory, the uncertainty principle, formulation of Schrodinger's equation, and the energy quantization of a free particle.

PH 244 **Optical Instruments** (1-2)2
[PH 205 taken concurrently]

The basic laws of optics and their application to various optical instruments used in industry, such as the microscope, telescope, refractometer, and colorimeter. Considerable emphasis in the laboratory work is placed on the general use of the microscope.

PH 251 **Intermediate Electricity** (3-3)4
[MA 205 and PH 205 taken concurrently]

Electric field, potential, Gauss's law, dipoles, Poisson's and Laplace's equations, image problems, dielectric theory, energy,

capacitance, force, electric current, d.c. circuits, steady magnetic fields, electromagnetic induction, magnetic properties of matter, L-C-R circuits, analysis of a.c. circuits, and Maxwell's equations.

PH 253-254 Introductory Field Theory (3-0) (3-0)6

[MA 108 and PH 104; MA 205-206 taken concurrently]

[For students majoring in Electrical Engineering]

The fundamental laws of electricity and magnetism presented from the point of view of field theory. Free use is made of the calculus. Electrostatics, steady currents and their magnetic fields, induced electromotive forces and inductance, time-dependent magnetic fields, and electromagnetic waves in free space, on wires, and in material bodies. Behavior of electrons in metals, thermionic emission, dielectric and magnetic properties of matter, geometrical optics, physical optics, atomic structure, and topics in modern physics.

PH 258 Electrical Measurements (2-3)3

[MA 205, PH 205]

Precision of measurements, zero-frequency and low-frequency measurements by both deflection and null methods, amplifiers and tube electrometers, oscilloscopes, oscillographs, Geiger and proportional counters, magnetic measurements, and electrical measurements in mechanics, heat, acoustics, optics, and nuclear science.

PH 311-312 Intermediate Mechanics (3-0)(3-0)6

[MA 206]

Vector analysis, statics of systems of particles, rectilinear motion of a single particle, the linear oscillator, motion in two and three dimensions, Stokes' theorem, conservative forces, central field motion, motion of systems of particles, generalized coordinates and momenta, Lagrange's equations, motion of rigid bodies, the spinning top, the coupled oscillator, normal coordinates, and the vibrating string.

PH 321 or 322 Intermediate Thermodynamics (3-0)3

[MA 206]

Analysis of temperature, thermodynamic systems, ideal gases, the first and second laws of thermodynamics, reversible processes, the Carnot cycle, entropy and its philosophical significance, properties of pure substances, and various applications.

PH 323 or 324 Introduction to Statistical (3-0)3
Mechanics

[PH 312 taken concurrently; PH 321]

Introduction to probability theory, classical Maxwell-Boltzmann statistics, classical statistical mechanics, statistical mechanical interpretation of thermodynamics, and applications to the kinetic theory of gases.

PH 343-344 Atomic and Nuclear Physics (3-0) (3-0)6
[MA 206, PH 206; PH 311-312 taken concurrently]

[For students in the Experimental Physics Option]

Atoms as components of matter; particle beams in electric and magnetic fields; and magnetic, optical, and electrical properties of atoms. X-rays, photons and X-ray spectra, optical spectra, the special theory of relativity, the Schrodinger equation, and electron spin and multiplet spectra. Radioactivity, Rutherford scattering, nuclear radii, wave mechanics, cross sections, and nuclear reactions.

PH 345-346 Atomic and Nuclear Physics (3-0) (3-0)6
[MA 206, PH 206; PH 311-312 taken concurrently]

The special theory of relativity; relativistic mechanics; scalar invariants, 4-vectors, and tensors; the Lorentz transformation and particle collisions; an introduction to quantum mechanics; and the one-electron atom. The Pauli exclusion principle; atomic shell structure, the multielectron atom, and atomic spectroscopy; the Zeeman effect, the Stark effect, and the Paschen-Back effect; basic properties of nuclei; charge, mass, and magnetic moments; radioactivity; and excited nuclear states and nuclear reactions.

PH 347 or 348 Physical Optics (3-0)3
[PH 353 or 354]

The theoretical and experimental aspects of the phenomena of interference, diffraction, and polarization of electromagnetic waves, especially light and microwaves.

PH 353-354 Electromagnetic Theory (3-0) (3-0)6
[MA 301-302 taken concurrently; PH 205]

The theory of electromagnetic fields using vector analysis and Maxwell's equations. Static electric and magnetic fields in dielectrics, conductors, and ferromagnetic materials; the scalar and vector potentials and time-varying fields; and the special theory of relativity. Plane waves in dielectrics and conductors, the Poynting vector, Fresnel's equations, and waveguides; radiation from antennas and accelerated charges; polarization, interference, and diffraction; and receivers.

PH 363 or 364 **Introductory Nuclear Physics** **(3-0)3**
[MA 206, PH 208]

[For students majoring in Nuclear Engineering]

Natural radioactivity; the Bateman equations; isotopic abundance; induced activity; the energetics of nuclear reactions; and alpha, beta, and gamma emission.

PH 365 or 366 Intermediate Nuclear Physics (3-0)3
[PH 363]

[For students majoring in Nuclear Engineering]

The compound nucleus and resonance theory, cross sections, Rutherford scattering, center of mass coordinates, neutron physics, nuclear radii, nuclear stability and forces between nucleons, and nuclear models.

PH 394 Physics Laboratory (0-3)1
[Permission of instructor]

The student is afforded an opportunity to perform significant experiments in various areas of physics.

PH 411-412* Quantum Theory (3-0) (3-0)6
 [MA 433 and MA 484 taken concurrently; PH 311 or 312]

The beginnings of the quantum theory. The Bohr-Sommerfeld theory; wave-particle dualities and the uncertainty principle; the DeBroglie theory; basic principles of wave mechanics; Schrodinger's equation and applications; operators and observables; commuting properties of operators and their relationships to the uncertainty principle; mathematical theory of eigenfunctions, Fourier series, and the Fourier integral; matrix mechanics; perturbation theory by wave and matrix mechanics; and applications.

PH 425 or 426 Meteorology (3-0)3
[MA 205]

Introduction to meteorological science; the atmosphere, clouds and precipitation, heat and temperature changes, radiation balance and global circulation, equations of motion, air masses and fronts, cyclones and tropical storms, and climatology; observations and analyses; maps and forecasts.

PH 431 or 432* Theory of Vibrations and Sound (3-0)3
[MA 301, PH 312]

Free, damped, and forced oscillations; forcing by pulses; coupled oscillations; the flexible string; end conditions; perturbations; the vibration of bars, membranes, and plates; sound waves; acoustic

impedance; the radiation and scattering of sound; normal modes; and reverberation. Applications are stressed.

PH 443 or 444 Spectrographic Methods (2-3)3
[PH 206]

A course exploring the merits of spectroscopy as a tool for the investigating scientist. The theoretical prediction of line and band spectra and the theory and operation of various spectrograph designs.

PH 445 or 446 X-Ray Diffraction (1-6)3

Theory of X-ray production; absorption; scattering by electrons and atoms; crystallographic notation; Laue equations; and determination of crystal structure. For those whose background interests involve fibers, some opportunity for investigation of these is offered in the laboratory work.

PH 447 or 448 **Electron Microscopy and** (2-3)3
 Electron Diffraction
 [PH 206]

Analogies with optics, electrostatic and magnetic lenses, electron trajectories, the scattering of electrons, electron diffraction and the wave properties of the electron, vacuum techniques, thin films by vacuum evaporation and electropolishing, specimen preparation, qualitative and quantitative evaluation of the electron image, and photographic techniques.

PH 449 or 450 Infrared Radiation (2-3)3
[PH 206]

The use of infrared radiation as a means of scientific investigation. The laws and theories of black body radiation, including those of Planck, Wien, and Stefan-Boltzmann. The theory and operation of various infrared detectors and systems of collecting optics.

PH 453 or 454 **Piezoelectric Crystals** **(2-3)3**
[PH 311, PH 353]

Phenomena in piezoelectric crystals and measurements of related quantities. Parameters of the equivalent circuit of a resonator, vibrational modes, elastic coefficients and temperature effects, the consequences of cutting plates of different orientations, and effects of surface shaping. Applications such as in transducers, frequency stabilization, ultrasonic wave generation, wave filtering, and clock control.

PH 461 or 462 Nuclear Physics (3-0)3
 [MA 302, PH 344 or 366]

Nuclear moments, parity and statistics, extranuclear effects of the nucleus, effects of nuclear moments and parity on nuclear transitions, nuclear barrier penetration, alpha decay theory with solution by numerical methods, beta decay systematics, and ionization of matter by charged particles.

PH 471-472* Solid-State Physics (3-0) (3-0)6
 [PH 411-412 taken concurrently]

Crystal structure and X-ray and neutron diffraction; free electron model; band theory of solids; quantum mechanical considerations; lattice energy, lattice vibrations, and infrared absorption; lattice defects; thermal properties of solids; dielectric and magnetic properties; mechanical properties; and semiconductor crystals.

PH 493-494 Advanced Laboratory (1-3) (1-3)4
 [Permission of instructor]

A laboratory course which accompanies the senior courses in the department and which may serve as a vehicle for undergraduate experimental research in selected fields of physics.

PH 495 or 496* Special Research Problems Credits to be arranged
 [Permission of Head of Department and instructor]

Special problems in theoretical and experimental physics assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

PH 497-498 Biophysics Seminar (1½-0)1

A seminar-type course with students leading discussions on almost any topic of physical interest in biology. An attempt is made to survey this vast field, but emphasis is mainly on the physics of the sense organs, nerve conduction, and muscle contraction; the effects of radiation on living cells; molecular biology; applications of information theory to biology; and descriptions of some of the newer instrumentation for research.

PH 509-510 Origin and Development of (3-0) (3-0)6
 Modern Theories

The history of the theory of atomic spectra, including X-ray spectra used as an illustrative example to explain the principles of scientific method.

PH 511-512	Classical Mechanics [PH 312]	(3-0) (3-0)6
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Lagrange's equations, Hamilton's principle, holonomic and non-holonomic constraints, the two-body problem, matrix formulation of rigid body motion, Hamilton's equations, principle of least action, canonical transformations, Hamilton-Jacobi theory, and the theory of small oscillations.

PH 513-514	Statistical Mechanics [PH 324]	(3-0) (3-0)6
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The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi-Dirac and Bose-Einstein, and applications to thermodynamics, solid-state physics, and nuclear physics.

PH 515-516 **Quantum Mechanics** **(3-0) (3-0)6**
 [MA 433, PH 411; PH 511-512 taken concurrently]

The properties of angular momentum and spin and the addition of angular momenta, perturbation theory, scattering theory, partial waves, group theory, the Klein-Gordon and Dirac equations, and spinors. An introduction to quantum electrodynamics and field theory.

PH 517 or 518 High-Energy Particles (3-0)3

The physics of high-energy particles, including the so-called strange particles.

PH 519-520 Problems in Quantum Mechanics (3-0) (3-0)6
[PH 412]

A study of some of the outstanding problems and advances in the field of quantum mechanics.

PH 523 or 524 Low-Temperature Physics (3-3)4
[MA 302; PH 321 or 322]

The production of low temperatures; temperature measurement; liquid helium; superfluids and superconductors; paramagnetic salts; the magnetic temperature scale; nuclear polarization and alignment; thermal conductivity at low temperatures; the third law of thermodynamics; and adiabatic demagnetization.

PH 531 or 532 Acoustics (3-3)4

Not offered in 1964-65.

PH 533 or 534 Crystal Vibrations (3-0)3
[MA 302, MA 433, PH 472]

Interatomic forces in crystals; the theory of lattice vibrations for one-, two-, and three-dimensional systems; and applications of quantum mechanics and statistical mechanics to crystal systems.

PH 537-538 Group Theory (3-0) (3-0)6

Group theory and its application to the quantum theory; symmetry properties and conservation laws, the theory of Lie groups, a thorough analysis of rotation and Lorentz groups, and the theory of unitary symmetry and its physical consequences.

PH 552 Astrophysics (3-0)3
[PH 206, PH 311]

The origin and future of the universe, using mathematical treatment wherever practicable. Theorems needed beyond the prerequisites are developed in the course.

PH 553 or 554 Piezoelectricity and (3-3)4
Ferroelectricity

Crystallographic bases of piezoelectricity, crystal elasticity, rotated axes, modes of vibration; behavior and interactions of the elastic, dielectric, and piezoelectric coefficients; ferroelectric crystals, domain structure, transitions between phases, free and clamped states; and applications of piezoelectric and ferroelectric crystals.

PH 555 or 556 Plasma Physics (3-0)3
[PH 353]

The production of high-energy electromagnetic and electrostatic fields and the interaction of these with conducting forms of matter. The physics of high-temperature, low-density gases, with emphasis on practical applications.

PH 557-558 Electricity and Magnetism (3-0) (3-0)6
[MA 301-302, PH 353-354]

The development of electromagnetic theory starting with Maxwell's equations and moving point charges. Static and time-varying fields of moving point charges, energy and momentum relations, solutions of the wave equation, and the special theory of relativity. Poynting's vector, waveguides, retarded fields, radiation from accelerated charges and antennas, the interaction of charged particles and electromagnetic fields, scattering and absorption cross sections, and applications of electromagnetic theory to masers.

PH 561 or 562 Nuclear Physics (3-0)3
[PH 462]

A theoretical course treating the general aspects of nuclear reactions. Alpha and beta decay. Nuclear models and recent advances in nuclear physics.

PH 563 or 564 Microwave Spectroscopy (3-3)4
Not offered in 1964-65.

PH 565 or 566 Nuclear and Electron Spin (3-3)4
Resonance Phenomena
[PH 411-412 taken concurrently]

An introduction to crystal field theory and electron spin resonance; coupling of angular momenta; nuclear electric quadrupole and magnetic resonance; application to gases, liquids, and crystals; and a survey of experimental techniques.

PH 567 or 568 Neutron Diffraction Analysis (3-0)3

The diffraction of neutrons in crystals and its applications in the determination of lattice structures and magnetic moments.

PH 571-572 Lattice Imperfections (3-0) (3-0)6

A description of point, line, and plane imperfections in crystals, and their properties, causes, and interactions; the influence of imperfections on electron and phonon transport phenomena and also on lasers; a study of imperfections by X-ray and electron diffraction; and a discussion of problems in current literature.

PH 575-576 Problems in Solid-State Physics (3-0) (3-3)7

Quantum mechanics and specific heats, lattice energy, elastic coefficients, applications of statistical mechanics, ferroelectric crystals, diamagnetism and paramagnetism, Brillouin zones, Hume-Rothery rules, order-disorder transformations, semiconductors, ferromagnetism and antiferromagnetism, ferrimagnetism, magnet relaxation and resonance, superconductivity, lattice vacancies, diffusion, color centers, excitons, dislocations, and thermal and electrical conductivity at low temperatures.

PH 577-578 Thermodynamics of Solids (3-0) (3-0)6

The thermodynamics of first- and second-order phase changes; lattice energy and vibration spectrum; the Einstein-Debye model; nonideal solid solutions; order-disorder phenomena; crystal interfaces and imperfections; and applications to metals and semiconductors.

PH 581 or 582 Information Theory (3-0)3

A definition of information and its identification with entropy; a critical examination of codes and written and spoken languages; the Tuller-Shannon formula and the capacity of channels with noise; and autocorrelation techniques and their application. Physical analogs of communications problems are stressed throughout.

PH 583-584 Relativity Theory (3-0) (3-0)6

The invariance of physical laws; tensor formulation of the special theory of relativity and applications; and the general theory of relativity.

PH 585-586 Classical Field Theory (3-0) (3-0)6

The theory of electromagnetic fields; elements of special relativity; the covariant formulation of Maxwell's equations; applications such as the classical treatment of the field of moving charges, radiation, scattering, and physical optics; and introduction to gravitational fields.

PH 589-590 Quantum Field Theory (3-0) (3-0)6

Review of the Dirac equation, the Foldy-Wouthuysen transformation, elements of covariant perturbation theory based on Feynman's propagator approach, and renormalization theory. Canonical commutation rules, connection between spin and statistics, the TCP theorem, and selected topics in strong and weak interactions.

PH 591 or 592 Graduate Thesis Credits to be arranged

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

PH 595-596 Physics Seminar Credits to be arranged

A discussion of timely topics by visiting scientists, staff, and graduate students. Required of all graduate students.

Plastics

PL 201 **Plastics Technology** **(2-0)2**

A descriptive subject to acquaint the student with plastics as a class of materials. The history, definitions, classes, properties, and applications of plastics.

PL 202 **Introduction to Polymeric Materials** **(2-0)2**

Continuation of PL 201.

PL 301-302 **Plastics Technology** **(2-2) (2-2)6**
[PL 201-202]

Raw materials and manufacturing processes. Methods of processing plastics materials, including compounding, molding, casting, extruding, laminating, fabricating, and finishing. Evaluation and development of typical plastics problems. Laboratory instruction in the processing and fabrication of plastics materials.

PL 401-402 **Plastics Technology** **(2-3) (2-3)6**
[PL 301-302]

Application of plastics as engineering materials. Product, equipment, and mold design. Correlation of composition, processing, and fabrication with product design and applications. Continuation of laboratory instruction in processing, molding, and fabrication.

PL 403-404 **Properties of Polymers** **(2-3) (2-3)6**
[Open to seniors only]

Correlation of composition and structure with important engineering properties of plastics; environmental conditioning and effects of types of loading in evaluation of plastics materials; the theory of testing; critical examination of testing techniques, equipment, and standard ASTM methods of evaluating mechanical, thermal, electrical, and optical properties.

PL 406 **Plastics Quality Procedures** **(3-0)3**
[MA 383 or 384]

Basic techniques of maintaining quality in the manufacture of plastic products. Quality assurance of incoming material and out-

going products as well as the methods of controlling process quality. Description of methods used in calculating tolerances, meeting specifications, and determining reliability.

PL 411-412

Plastics Seminar

(1-0) (1-0)2

[Open to seniors only]

Informal discussions, based on literature study conducted by the individual, of topics in, or related to, plastics technology.

Social Sciences

- SS 102 Foundations of National Power (2-0)2**
[For non-ROTC freshmen only]

The principles of United States foreign policy and the role of the country in contemporary world politics.

- SS 223-224 The United States Since 1865 (2-0) (2-0)4**

The study of the advancement of the American people from the Reconstruction era to the present. With special permission the first semester may be taken alone for credit.

- SS 225 or 226 Europe: 1789—1914 (3-0)3**

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the French Revolution, the Industrial Revolution, social and political reforms, the rise of nationalism and imperialism, and the background of World War I.

- SS 227 or 228 Europe Since 1914 (3-0)3**

A review of the backgrounds of both World Wars and the postwar periods, with emphasis on such topics as the rise and development of totalitarianism, postwar efforts to establish international agencies, and changes in economic, political, and social institutions.

- SS 301 Government of the United States (3-0)3**

The process of policy-making in Congress and the Presidency with particular attention to the location of power in the government, both in theory and in practice.

- SS 302 Conduct and Control of Foreign Policy (3-0)3**

A seminar considering the ways a state's conduct of its foreign policy affects, and is affected by, both the substance and processes of its domestic politics. Primary consideration is given to the United States and the principal nations of Western Europe, but examples are taken from other nations as well.

- SS 303 or 304 Psychology (3-0)3**

The place of psychology in the life of the individual and society, with emphasis on the psychological bases of behavior and attitude in their relations to personal, industrial, and community experiences.

- SS 305 or 306 Sociology (3-0)3**
 The principles of sociology, including the development of man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.
- SS 371 or 372 American Civilization to 1865 (3-0)3**
 A study of the development of national consciousness in America through a review of the evolution of economic, political, and social institutions and their influences upon U. S. culture.
- SS 403 World Politics: Principles, Structures, Cases (3-0)3**
 An examination of theories of international relations as a framework for an analysis of the elements, organization, strategies, and controls of world politics by a historical case method.
- SS 459 World Politics: The Central Problem of War (3-0)3**
 War as the central phenomenon of world politics—its causes and functions in theory and history, its effects on the individual and society, efforts to control it, and ethical problems raised by it.
- SS 460 Foreign Aid and Foreign Policy (3-0)3**
 A seminar considering the difficulties involved in stabilizing areas threatened by communism and insurgency which lie outside the line of containment. Discussions involve changing approaches to foreign aid, and relations of western powers, Congress and the State Department, and various other departments and agencies involved in foreign policy operations.
- SS 464 World Politics: Problems of International (3-0)3**
Organization
 International and regional organizations both as mirrors of contemporary world politics and as forces of change. The history and theories of international organization, constitutional problems, the political and non-political functions of the UN system; the development, varieties, and significance of regionalism; and the relations between traditional and parliamentary diplomacy.
- SS 471 The United States in World Politics (3-0)3**
 The principles behind American foreign policy and an eclectic inquiry using a case study into the circumstances under which these principles have been utilized by the United States.
- SS 472 Defense Policy (3-0)3**
 A seminar revolving around the relationship of force and foreign policy in the thermonuclear age. Discussions involve policy-making and organization, military strategy and foreign policy, and the substance of national security.

SS 477 or 478 Twentieth-Century Russia (3-0)3

The objective of this subject is twofold: to give the student an understanding of the Russian people, the Empire, and the Soviet Union through a study of backgrounds, and to make possible a comprehension of the structure, aims, and methods of the Soviet regime and its present role in world affairs.

SS 479 or 480 The Far East Since 1900 (3-0)3

Basic historical and cultural backgrounds of the peoples of East Asia surveyed as a preface to a study of the economic, political, and social development of the mainland and island states, with emphasis on the interests and policies of European nations and the United States.

SS 481 or 482 The Greeks and Western Civilization (3-0)3

Contributions of the ancient Greeks to our culture. The influences of Greek thought, arts, and politics studied through selected readings and discussions in seminar meetings.

SS 483 Political and Social Thought: Ancient Times to Early Modern Times (3-0)3

Studies in the works of great writers of political and social philosophy from Plato through Machiavelli. Class discussion with the purpose of tracing the origins and development of humanism, asceticism, communism, fascism, and democracy.

SS 484 Political and Social Thought: Early Modern Times to Present (3-0)3

Studies in the origins and development of modern political and social ideologies. Class discussion with the purpose of relating ideologies to institutional conflicts.

SS 485 or 486 The Romans and Western Civilization (3-0)3

Roman contributions to western culture and politics, with emphasis on Roman legal and governmental concepts and institutions.

SS 487 American Political Thought to 1865 (3-0)3

A study of those events which have shaped American political thought, with emphasis upon the American Revolution, the Constitution, and the Civil War.

SS 488 American Political Thought Since 1865 (3-0)3

An examination of the evolution of the American political tradition in the modern age, with special attention to the reform movement, the Roosevelt era, and the postwar years.

Textile Chemistry

TC 201 Introduction to Textiles (2-0)1

The history, economics, and geographical distribution of the textile industry and its interrelationships with the chemical and fiber-producing industries. The basic principles, nomenclature, and sequences of the physical and chemical processes of the textile industry.

TC 202 Chemistry and Physics of Fibers (3-0)3

The structure and chemical reactions of linear high polymers of importance in the field of natural and synthetic fibers; the chemical and physical structure of polymers and fibers; the relation of molecular length, orientation, crystallinity, intermolecular attractions, side chains, and flexibility of polymers to the physical properties of fibers; and chemical reactions of polymers and their effects on fibers.

TC 301 The Purification of Fibers (2-3)3

The chemical and physical nature and properties of impurities in natural and man-made fibers and the mechanisms of their elimination. The theory and principles of fiber purification discussed in lectures are evaluated by laboratory and pilot-plant experimental study.

TC 311 Chemical Textile Testing (3-0)3

Qualitative and quantitative methods for determining fiber content, finishing agents, and dyestuffs, including optical methods of analysis and evaluation.

TC 401* Textile Seminar (2-0)1

Unit operations involved in the manipulations and processing of fibers, yarns, and fabrics.

TC 403 The Principles of Dyeing and Printing (2-6)4

The principles of dyeing and printing commercially important fibers with the more important classes of dyes and pigments. Lectures, laboratory experimentation, and pilot-plant problems are integrated to illustrate basic principles of dyeing methods, color prediction, compatibility of dyes in mixtures, basic variables of machine design, the control of nonuniformity, and the principles of phase transfer of dyes in printing.

TC 404 Theory of Dyeing (3-4)4

Mechanisms of reactions in the dyeing of fibers which emphasize basic physical and chemical variables affecting equilibria, rates of dyeing, and diffusion. Quantitative studies on the kinetics and equilibria of dyeing reactions are conducted in the laboratory.

TC 411 Chemical Technology of Finishing I (3-1)3

Conversions of fabrics from the gray state for utility, serviceability, or appearance. Stress is placed both on the chemical phases and on essential engineering principles. Lectures, seminars, and laboratory workshops.

TC 412 Chemical Technology of Finishing II (3-2)4
Continuation of TC 411.

TC 502 Theory of Dyeing (3-4)4

Mechanisms of reactions in the dyeing of fibers which emphasize basic physical and chemical variables affecting equilibria, rates of dyeing, and diffusion. Quantitative studies on the kinetics and equilibria of dyeing reactions are conducted in the laboratory.

TC 505 Physical Chemistry of Dyeing (3-0)3

Lectures and exercises on the physicochemical principles involved in the application of dyestuffs to textile materials, including both the thermodynamics and kinetics of dyeing.

TC 541-542 Graduate Thesis Credits to be arranged

An independent investigation of a problem in textile chemistry in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

TC 555-556 Textile Chemistry Graduate Seminar (2-0) (2-0)4

A series of informal discussions of current problems in research and technology in the textile chemistry field. Special investigations of the literature serve as a source of seminar topics.

Textiles

TE 212 **Fiber Science** **(3-1)3**

The different fibers and their origin and properties. The effect of molecular arrangement in fibers upon the chemical, physical, and mechanical behavior of the raw material and upon their technological utilization. Polymer structure, order, intermolecular forces, flexibility, and other properties in the light of stress-strain relationships, such as viscoelastic behavior. These and other factors as design elements leading to the prediction of the physical properties of textile systems, as well as the geometry of yarns and fabrics and their behavior characteristics.

TE 322 **Yarn Technology** **(2-2)3**

Advanced processing techniques, with the use of equipment illustrating all systems common to the U. S. standards.

TE 363 **Textile Systems I** **(3-1)3**

Fiber preparation processes as systems in yarn manufacture presented analytically in terms of engineering principles or mechanisms leading to an understanding of the functional use, structural design, and basic geometry of yarns.

TE 364 **Textile Systems II** **(3-2)3**

The concepts of fabric design: an analysis of the effects of mechanical processing upon structural relationships, with stress on physicommechanical and chemical behavior.

TE 366 **Textile Systems III** **(2-1)2**

A study and analysis of the physical behavior of gray fabrics as mechanical systems during the finishing operations. Major emphasis is on absorption, pressure, heat transfer, and the physical and mechanical design principles involved. Laboratory is demonstration only.

TE 367 **Textile Systems IV** **(2-1)2**

The basic chemical structure of the fibers within the fabric and the relationship which such a system has with the application of dye and finish due to chemical transition catalysis, electrostatic attraction, covalent and other bonding forces, etc., in effecting an acceptable end product.

TE 411-412 **Fundamentals of Textiles—Yarns** **(2-2) (2-2)6**

Designed to familiarize students with the basic machines and techniques for the production of yarns regardless of the fibers and/or production systems used. Primary emphasis is upon the mechanical principles employed.

TE 431-432 Fundamentals of Textiles—Fabrics (2-2) (2-2)6

Designed to familiarize students with the basic machines and techniques for the production of fabrics regardless of the fibers and/or yarns employed, from the preparation of yarns for fabrication to the actions and modifications available for the production of fabrics. Primary emphasis is upon the mechanical principles employed.

TE 435 **Fabric Technology** **(3-2)4**

A thorough study of design, weaving, and knitting as applications of science to the construction of fabrics.

TE 459-460 Technology of Finishing (3-1) (1-2)5

Lectures and laboratory workshops in the major engineering and chemical considerations necessary to finish fabrics of all fibers. The engineering aspects are stressed.

TE 471 or 472 Textile Evaluation (2-3)3

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equilibrium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 474 Instrumentation for Textiles (2-2)3
[EE 204]

[EE 204]

A study of indicating and recording instruments used to measure such common textile process variables as pressure, temperature, humidity, liquid level, fluid flow, etc. Response characteristics of mechanical, electrical, and electronic systems, and process characteristics and their effects upon the selection of the correct mode of control.

TE 482 Application of Scientific Methods to (3-0)3
 Textile Processes
 [MA 206, ME 341]

Textile Processes

[MA 206, ME 341]

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems

of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483-484* Engineering Design of Textile (3-0) (3-0)6
Structures
[MA 205, TE 364]

This subject correlates engineering properties of textile materials, engineering principles, and textile processing in the design of textile structures with desired properties. The geometry of yarns and fabrics; design of textile structures for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes which the end use imposes; analyses of load-elongation diagrams of textile structural material.

TE 501-502 Structure and Properties of Fibers (3-0) (3-0)6
[Permission of instructor]

The molecular structure and arrangements of molecules in fibers are considered with respect to giving a foundation to the understanding of the physical and mechanical properties and behavior of these textile raw materials. These properties are examined from a fundamental viewpoint so that a sound approach to the technological utilization of fibers in textiles can be established. Such aspects as polymer structure, order, intermolecular forces, and flexibility, as they relate to stress-strain characteristics, viscoelastic behavior, etc., are discussed as well as the effects of environmental conditions on these factors. An introduction is made to the interrelation between fiber properties and yarn and fabric geometry in determining the behavior of textiles.

TE 503 or 504 Technology of Cotton Fibers (2-2)3
[Permission of instructor]

Effects of various chemical, mechanical, and growth modifications of cotton on the chemical, physical, and processing properties of the cotton fiber. Problems are assigned for laboratory evaluation, and a paper for class delivery is required of each student.

TE 517 or 518 Product Quality: Cotton (2-2)2
System Yarns
[Permission of instructor]

Devoted to a study and analysis of product defects in the manufacture of yarns on cotton system machinery. Procedures necessary to avoid the defects are studied, and the diagnostic ability of the student to recognize and remedy defects is developed.

TE 519 or 520 Multifiber Processing: Cotton (2-2)2
System Yarns
[Permission of instructor]

The blending and processing of various fibers utilizing cotton system machinery, with emphasis upon fiber properties and yarn characteristics.

TE 537 or 538 Fundamentals of Jacquard (1-1)1
Fabrics
[Permission of instructor]

Sketching of original designs as applied to particular Jacquard fabrics, transfer of design to cross-section design paper, choice of weave structure for both the background and foreground, cutting and lacing of cards, and weaving of sample lengths of fabric.

TE 539 or 540 Complex Woven Structures (2-1)2

A study of Leavers lace design and production theory, production machinery, and manufacture. The same aspects of Schiffli embroidery are covered, as well as the fundamentals pertaining to chenille, Wilton, Brussels, tapestry, velvet, and Axminster carpets.

TE 545 or 546 Weaving Laboratory (0-3)1
[Permission of instructor]

Designed to provide additional time for the student in the weaving laboratory so that greater familiarization with the operation of various loom mechanisms may be acquired.

TE 571 Textile Microscopy (2-3)3

The principles involved in the use of the microscope for the qualitative and quantitative estimation of the morphological, physical, and chemical properties of textile materials.

TE 573 or 574 Mechanical Testing of (2-3)3
Textiles

Thickness and compressional measurements, stress-strain-time phenomena of viscoelastic textile materials, Vibroscope theory and techniques, yarn uniformity, thermal determination, and friction evaluation are among the major topics covered. Emphasis is placed on current literature search assignments and the preparation of a student paper on a selected topic within the scope of the subject.

TE 585 Textile Plants Organization—Yarns (3-0)3

Designed to correlate the various aspects of yarn production. Emphasis is placed upon the need for proper balance among machinery elements for the production of specific yarn types. Consid-

eration of machinery layouts for efficient and economic operation of the total yarn establishment, with stress on the various calculations involved. Considerable use is made of the case history technique of presentation.

TE 586 Textile Plants Organization—Fabrics (3-0)3

Similar in concept to TE 585 except that the subject pertains to the production of fabrics.

TE 590 Graduate Seminar (2-0)0

Introduction to thesis material and thesis preparation.

TE 591-592 Thesis Seminar (2-0) (2-0)2

Required of all graduate students in Textile Engineering during their thesis year. Devoted to problems in the preparation and presentation of research work, with illustrative material drawn from thesis work in process.

TE 593-594 Graduate Thesis Credits to be arranged

Each graduate student in Textile Engineering is required to submit a thesis which shows ability and originality in the solution and presentation of a research project.

THE GRADUATE SCHOOL

INTRODUCTION

The Lowell Technological Institute Graduate School, founded in 1935, offers the degree of Master of Science in the following fields:

Chemistry	Paper Engineering
Electrical Engineering	Physics
Leather Chemistry	Textile Chemistry
Mathematics	Textile Technology
Mechanical Engineering (to be offered 1965-1966)	

In addition the School offers a program leading to the Doctor of Philosophy degree in Chemistry with options in organic and physical chemistry.

Because of the varied objectives of the graduate students, each specific course of study is arrived at through consultation with the student's graduate adviser or advisory committee. Each program includes an original thesis.

ADMISSION

General Admission

To be eligible for admission to the Graduate School, an applicant must have received a bachelor's degree in an acceptable four-year course in which he has maintained a uniformly high scholastic rating. Both the quality and quantity of previous training are considered. Selection of applicants admitted is based upon their ability to pursue graduate work of high quality.

Special Student Status

An applicant who meets the general admission requirements but who wishes to concentrate on specific subjects or special research programs may request special student status. Acceptance is contingent upon the consent of the instructor in charge of each subject to which admission is desired, and the work does not lead to a degree.

Normally a special student may not change his status to that of a student working for a graduate degree. If a special student wishes to work for a degree, he must apply in writing to the Director of the Graduate School. If the application for change in status is approved, all of the credit earned as a special student may not necessarily be allowed for degree credit.

Provisional Status

An applicant for admission who is unable to meet all the requirements for general admission may be accepted provisionally if he satisfies the department in which he wishes to enroll that he is probably able to pursue graduate studies successfully.

The status of a provisional graduate student may be changed to full graduate status upon demonstration of his ability to pursue graduate studies successfully as measured by the completion of his first semester's work with a minimum of a B— average in subjects taken for credit toward the graduate degree.

Application Procedure

Applications may be obtained from the Office of the Graduate School. They should be completed and returned to the Director of the Graduate School not later than June 1 preceding the fall term in which the applicant wishes to enroll. Applications must be supported by letters from at least two persons qualified to judge the ability of the applicant to carry on graduate work and research. The letters should be sent directly from these persons to the Graduate School.

Transcripts of all undergraduate records (and graduate, if any) must be sent directly to the Office of the Graduate School by the institutions which the applicant has previously attended. All transcripts must be official, with appropriate seals and signatures. Records, descriptions of subjects, and letters must be in English. Each subject must be described in terms of content, scope, number of hours per week, and number of weeks duration. Lecture and laboratory time should be properly distinguished. If a catalogue giving such descriptions in English is available, the subjects taken may be clearly marked in a copy sent to the Graduate School.

Credit may be given for graduate subjects taken at other colleges if the grade received is at least B and if these subjects were not used in earning another degree. All applicants must submit an additional copy of transcripts which include the subjects for which transfer credit is desired. Not more than 10 credit hours for the master's degree or more than 22 credit hours for the doctor's degree may be transferred. No transfer credit can be offered for the thesis requirement for any graduate degree. Transfer credit for subjects taken at other colleges before initial enrollment at Lowell Technological Institute must be cleared within four weeks after the student's first registration. No transfer credit for such subjects is given after this period.

In addition to returning a completed application form and having transcripts and letters sent, the applicant must take the Graduate Record Aptitude Test and have the results sent to the Director of the Graduate School. Information regarding the Gradu-

ate Record Aptitude Test may be obtained from Educational Testing Service, 20 Nassau Street, Princeton, N. J., or Box 27896, Los Angeles 27, Cal., whichever office is nearer to the applicant. All fellowship applicants must also take the appropriate Advanced Test administered by the Educational Testing Service.

Because most subjects are presented in lecture form, students from other countries should have a reasonably fluent command of the English language before applying for admission. All students from countries where English is not the national language must pass an English Language Proficiency Test before they can be accepted into the Graduate School. This test may be taken at any U. S. consular office.

Except in unusual circumstances, applications are acted upon and the applicant is notified of the decision by July 1. Foreign applicants are urged to apply as early as possible so as to leave enough time for visa and other arrangements to be made.

EXPENSES

Tuition (per year)	
U. S. citizens who are residents of Massachusetts	\$200
U. S. citizens who are residents of other states	300
All others	550
Student Activity and Insurance Fund (per year)	49
Commencement Fee	15

In addition, every graduate student is required to bear the cost of binding at least two copies of his thesis for the Institute's files. Some divisions may require more than two bound copies. Students are not permitted to register for thesis work until these fees have been paid at the library.

FELLOWSHIPS

Teaching Fellowships

A limited number of part-time instructorships are available to qualified students working toward a graduate degree. Stipends range from \$1500 to approximately \$2500 per academic year, depending on the nature of the appointment, and reappointment in succeeding years is contingent upon satisfactory performance of duties. Appointees are expected to carry up to a half-time teaching load primarily involving supervision of undergraduate laboratories and review sections.

Research Fellowships

The Lowell Technological Institute Research Foundation sponsors a limited number of research fellowships for graduate study in Physics. A stipend of \$2500 plus tuition and fees is granted for one calendar year. The recipient carries a full graduate program

during the fall and spring semesters and conducts his thesis investigation during the summer.

All applicants for these fellowships must take the Advanced Graduate Record Examination in Physics as well as the Aptitude Tests. No special applications are required, but applicants must submit their graduate school applications, transcripts, and letters of reference to the Director of the Graduate School no later than April 1. In addition, they should plan to take the Graduate Record Examinations in March or earlier.

National Science Foundation Cooperative Graduate Fellowships

The Institute is a participant in the National Science Foundation's Cooperative Graduate Fellowship Program. These fellowships are awarded on the basis of ability. Candidates must be citizens of the United States on or before March 1 following the submission of their applications and must be admitted to full graduate status by the Institute prior to beginning their fellowship tenures.

The stipend provided by the NSF for Cooperative Graduate Fellows is \$2200-\$3000 for those on a tenure of 12 months and \$1650-\$2250 for those on a tenure of nine months. There is also an allowance of \$500 for each dependent. Tuition and fees are paid by the NSF directly to the Institute.

One of the requirements for applying for an NSF Fellowship is to take the Educational Testing Service Graduate Record Examinations (Aptitude Test and one Advanced Test in the area of specialization). Because the application deadline for the fellowships is in the first part of November, it is important to make arrangements to take these tests early.

MASTER OF SCIENCE DEGREE PROGRAMS

Chemistry

This program provides opportunity for advanced study and research training in chemistry, both general and specialized. Provision also is made for the student to elect certain advanced subjects in related fields of mathematics, physics, and engineering.

Evaluation Examination—During the weeks of registration each entering student must present himself for four three-hour written evaluation examinations in the fields of organic chemistry, physical chemistry, inorganic chemistry, and analytical chemistry. In addition he must take a laboratory proficiency examination. These examinations are scheduled and administered by the Department of Chemistry, and the results serve as a guide for the student and advisory committee in planning the program of study.

All entering students must take these examinations regardless of previous training.

Subject Requirements—Of the 20-credit minimum, exclusive of thesis and seminar, required in listed subjects (see Requirements for Graduation) a minimum of 15 credits must be taken in chemistry. Of these not more than 12 credits may be taken in approved undergraduate subjects, although normally credit is not allowed for undergraduate subjects in the major field of specialization, e.g., organic, physical, inorganic. Recommended subjects include CH 423-424*, CH 431-432*, CH 443-444*, and all 500 courses in chemistry. Each graduate program must include subjects in organic chemistry, inorganic chemistry, and physical chemistry. All students must take CH 507-508, Chemistry Seminar. The remaining credits (five or more) may be taken in chemistry or in a related field such as physics, mathematics, or engineering. All subjects must be approved by the student's advisory committee.

Language Requirements—The student must demonstrate his ability to read technical German. For details concerning the language examination, see the section on Doctor of Philosophy Degree Program.

Advisory Committee—The development of the student's program of study is the responsibility of an advisory committee consisting of three members from the faculty of the Division of Chemistry and Applied Chemistry. This committee is appointed by the Director of the Graduate School upon the recommendation of the division chairman and includes the thesis supervisor.

Thesis Examination—Each candidate for the Master of Science degree in Chemistry, upon completion of his thesis, must present himself for an oral examination in the field of his thesis before an examination committee appointed by the department head and consisting of his advisory committee and other appropriate faculty members. While only members of the examination committee and the Director of the Graduate School may conduct the examination, all faculty members may attend. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the last semester. Each student has the right to one re-examination within a period of one year.

Electrical Engineering

This graduate program offers to a limited number of selected students opportunity for individualized work in the more advanced areas of electronics with emphasis on analytic methods of analysis and synthesis.

Leather Chemistry

Opportunity for graduate research in Leather Chemistry is provided through this program. In general only those students either possessing the B.S. degree in Chemistry or having a strong background in chemistry are acceptable as candidates for the M.S. degree.

The curriculum in Leather Chemistry is similar to that required for the M.S. degree in Chemistry, and subject requirements are identical. No language requirement is involved, but CH 507-508, Chemistry Seminar, must be taken each semester the student is in residence. Opportunity is provided for conducting research in chemistry as applied to the composition and technology of leather, and laboratory facilities for processing and testing leather are available.

Each student upon entering the curriculum must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry.

Thesis Examination—Upon completion of the thesis, each candidate for the degree of Master of Science in Leather Chemistry must present himself for an oral examination in the field of his thesis to an examination committee appointed by the department head. This examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester.

Mathematics (see Physics and Mathematics)

Paper Engineering

The graduate program in Paper Engineering is for the purpose of giving advanced work in papermaking, paper-converting, or allied fields.

The Paper Engineering Department will consider graduate students in the following categories:

- (a) graduates of the Lowell Technological Institute B.S. Paper Engineering program;
- (b) B.S. graduates in Paper Engineering or Paper Technology from other universities;
- (c) general B.S. or M.S. graduates in Engineering or Chemistry with no previous training in Paper Engineering.

Students with the backgrounds of (a) or (b) should be able to complete the work in one academic year. Students in group (c) should be able to complete the degree requirements in two academic years.

In the following suggested curriculum those subjects designated by a dagger (†) represent minimum degree requirements.

First Semester

CH	503†	Chemistry of High Polymers	(3-0)3
PA	301	Pulp Systems	(3-0)3
PA	303	Pulp Systems Laboratory	(2-6)4
		Technical Elective†	(3-0)3
			<hr/>
			Total hours (11-6)13

Second Semester

CH	334	Colloid Chemistry	(3-0)3
CH	504†	Chemistry of High Polymers	(3-0)3
CHE	204	Industrial Stoichiometry	(3-0)3
PA	302	Paper Systems	(3-0)3
PA	304	Paper Systems Laboratory	(1-6)3
			<hr/>
			Total hours (13-6)15

Third Semester

PA	403	Converting Processes	(3-0)3
PA	405	Converting Processes Laboratory	(0-6)2
PA	501†	Graduate Thesis	4
		Two Technical Electives†	(6-0)6
			<hr/>
			Total credit hours 15

Fourth Semester

CH	512†	Physical Chemistry of Surface-active Agents	(2-0)2
CH	538†	Rheology	(2-0)2
PA	502†	Graduate Thesis	4
		Technical Elective†	(3-0)3
			<hr/>
			Total credit hours 11

Additional undergraduate subjects may be required of students who have deficiencies in their prior training. Technical electives generally lie in the area of chemistry, applied chemistry, and mathematics and must be approved by the head of the Department of Chemical Engineering and Paper Engineering.

Physics and Mathematics

The graduate programs in Physics and Mathematics provide an opportunity for advanced study and the development of research capacity in physics or mathematics or both. The laboratories of the department are well set up for investigations in crystal physics and other aspects of solid-state physics, with excellent equipment in X-rays, spectroscopy, and electron microscopy. Equipment in nuclear physics is constantly being added.

Subject Requirements—Of the 20-credit minimum, exclusive of thesis, required in listed courses (see Requirements for Graduation) 15 credits must be taken in physics and mathematics. The remaining credits (five or more) may be taken in a related field.

Of the total credits at least 12 must be in subjects numbered 500 and above. A reasonable and consistent program of study is prepared by the student and his advisory committee. This committee consists of two or more members from the faculty of the Division of Physics and Engineering Science, one of whom is the thesis supervisor. The committee is appointed by the department head. Entering students who are found to be deficient in any areas of the undergraduate curriculum in Physics may be required to take appropriate courses in that curriculum.

Language Requirements—The student must demonstrate his ability to read technical German or Russian.

Thesis Examination—Each candidate for the Master of Science degree in this department, upon completion of his thesis, must present himself for an oral examination in the field of his thesis to an examination committee appointed by the department head and consisting of his advisory committee and other appropriate faculty members. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the last semester. Each student has a right to one re-examination within a period of one year.

Textile Chemistry

The graduate program in Textile Chemistry provides opportunity for advanced study and research in chemistry as applied to textiles and textile auxiliary agents. Formal subjects and research facilities are provided for training in fiber science and in the chemistry of the various processing operations applied to fibers, yarns, and fabrics, including dyeing, finishing, and fiber modifications.

Each student upon entering the curriculum must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry.

The M.S. degree in Textile Chemistry normally requires two years for completion except in those instances where the student possesses previous training in this field sufficiently extensive to meet departmental standards. In the following suggested curriculum those subjects designated by a dagger (†) represent minimum degree requirements.

First Semester

CH	331	Physical Chemistry	(3-3)4
MA	383	Statistical Methods	(3-0)3
TC	301	The Purification of Fibers	(2-3)3
TC	403	The Principles of Dyeing and Printing	(2-6)4
TC	411	Chemical Technology of Finishing I	(3-1)3
			<hr/>
Total hours			(13-13)17

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	334	Colloid Chemistry	(3-0)3
TC	202	Chemistry and Physics of Fibers	(3-0)3
TC	404	Theory of Dyeing	(3-4)4
TC	412	Chemical Technology of Finishing II	(3-2)4
			<hr/>
Total hours			(15-9)18

Third Semester

CH	505	Interpretation of Data	(3-0)3
TC	505	Physical Chemistry of Dyeing	(3-0)3
TC	541	Graduate Thesis	5
TC	555	Textile Chemistry Graduate Seminar	(2-0)2
			3
			<hr/>
Total credit hours			16

Fourth Semester

CH	502	Absorption Spectrophotometry and Color Measurement	(2-3)3
CH	512	Physical Chemistry of Surface-active Agents	(2-0)2
CH	538	Rheology	(2-0)2
TC	542	Graduate Thesis	5
TC	556	Textile Chemistry Graduate Seminar	(2-0)2
			<hr/>
Total credit hours			14

Depending upon previous baccalaureate preparation, exemptions on some of the above subjects may be allowed. However, no exemptions will be allowed on any graduate subject (subjects with numbers in the 500's).

Textile Technology

This graduate program is offered to qualified students in the field of textiles, with primary emphasis upon either the engineering or physical aspects of the field. Ample opportunity is afforded for study and research in the physical and mechanical properties of fibers and textile structures and methods of evaluating them. Work at an advanced level on the structural design of textiles, processing

principles, and manufacturing equipment is also available. Applicants should have a B.S. degree in Textile Engineering or Technology, Mechanical Engineering, or Electrical Engineering. Applicants with degrees in other areas, however, are given consideration.

Diagnostic Examinations—All entering students who have had previous training in Textile Technology are required to take diagnostic examinations during registration week. The subject areas tested are Fundamentals of Yarns, Fundamentals of Fabrics, Finishing Statistics, and Statistical Quality Control. Students are required to take diagnostic examinations only in subjects in which they have had previous training. Those who demonstrate proficiency in diagnostic examinations are exempt from taking the corresponding subjects during their program at the Institute.

Subject Requirements—The following suggested curriculum requires no previous textile training. Students who demonstrate proficiency in diagnostic examinations are exempt from taking the corresponding subjects. Students whose background is deficient in engineering or mathematics are required to take additional subjects. Those subjects designated by a dagger (†) represent minimum degree requirements.

First Semester

MA	383	Statistical Methods	(3-0)3
TE	411	Fundamentals of Textiles—Yarns	(2-2)3
TE	431	Fundamentals of Textiles—Fabrics	(2-2)3
TE	459	Technology of Finishing	(3-1)3
TE	471	Textile Evaluation	(2-3)3
Total hours			(12-8)15

Second Semester

IM	484	Statistical Quality Control	(3-0)3
TE	412	Fundamentals of Textiles—Yarns	(2-2)3
TE	432	Fundamentals of Textiles—Fabrics	(2-2)3
TE	460	Technology of Finishing	(1-2)2
TE	474	Instrumentation for Textiles	(2-2)3
TE	590	Graduate Seminar	(2-0)0
Total hours			(12-8)14

Third Semester

TE	483*†	Engineering Design of Textile Structures	(3-0)3
TE	501†	Structure and Properties of Fibers	(3-0)3
TE	571†	Textile Microscopy	(2-3)3
TE	585†	Textile Plants Organization—Yarns	(3-0)3
TE	591†	Thesis Seminar	(2-0)1
TE	593†	Graduate Thesis	3

Total credit hours 16

Fourth Semester

TE 484*	†Engineering Design of Textile Structures	(3-0)3
TE 502†	Structure and Properties of Fibers	(3-0)3
TE 574†	Mechanical Testing of Textiles	(2-3)3
TE 586†	Textile Plants Organization—Fabrics	(3-0)3
TE 592†	Thesis Seminar	(2-0)1
TE 594†	Graduate Thesis	3

Total credit hours 16

Thesis Examination—Each candidate for the Master of Science degree in Textile Technology, upon completion of his thesis, must take an oral examination in the field of his thesis. This examination is conducted by a committee appointed by the Director of the Graduate School which must include the thesis supervisor and advisers of the candidate and any additional faculty members desired by the Director. Any faculty members may attend, but only members of the examination committee may conduct the examination. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the semester in which the student expects to be a candidate for the degree. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the designated semester. If the student fails the oral examination, he has the right to one re-examination within a period of one year. Failure in the re-examination requires the satisfactory completion of a new thesis subject and the accompanying oral examination.

MASTER OF SCIENCE DEGREE REQUIREMENTS

Term of Residence

Applicants with sufficient background in their chosen field of concentration normally require one academic year of residence to complete the requirements for the master's degree. Those with no background require a minimum of two years of residence.

Graduates of other colleges usually need more than one academic year to fulfill the degree requirements, even though they majored as undergraduates in their graduate field of specialization.

All requirements for the master's degree must be completed within five years after the student's entrance. Extension of time beyond this limit may be granted only with joint approval of the student's adviser (or advisory committee), his department head, his division chairman, and the Director of the Graduate School.

Requirements for Graduation

To be recommended for the Master of Science degree a candidate must:

1. Complete a course of study approved by the department in which he has been enrolled. The approved course of study

must have a minimum of 30 credit hours, including thesis. A minimum of 20 credit hours must be spent in listed subjects, and the program should have no fewer than five credit hours of thesis work.

2. Complete a thesis (original research or other investigation, optional with the department) approved by the department in which he has been enrolled, and successfully pass any oral or written examinations on his thesis required by the department at the time his thesis is submitted for final approval. The only grades given for thesis work are S (satisfactory) and U (unsatisfactory). All theses should be submitted in final form to thesis advisers on or before May 15.
3. Maintain residence for at least one academic year.
4. Maintain at least a B— average in all work in formal subjects offered for the degree. The lowest grade acceptable for graduate credit is C. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work but which are taken during his enrollment as a graduate student must be passed with a grade of at least C; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.
5. Fulfill departmental language requirements.
6. Satisfy all requirements as to tuition and fees.

DOCTOR OF PHILOSOPHY DEGREE PROGRAM

Chemistry

The doctoral program in Chemistry is designed to provide both advanced knowledge and research training in chemistry, particularly in the fields of organic and physical chemistry and polymer science, with emphasis in the field of textiles for those so desiring.

Plan of Program

The doctoral degree normally requires from three to four years of study beyond the bachelor's degree or a minimum of two to three years beyond the master's degree.

The plan of study pursued by each student is dependent on individual requirements and is developed through conference with his advisory committee or, pending its appointment, with his temporary adviser.

All students entering the doctoral program must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry. Only those students who have taken these examinations previously as candidates for the Master of Science program will be excused.

The initial part of the student's program, normally completed at the end of two years of study, is devoted to formal course work. His first year is usually given to subjects in the major branches of chemistry in preparation for his qualifying (candidacy) examinations. The second year is devoted primarily to advanced subjects in a special field of concentration in preparation for the comprehensive examinations.

The second and final part of the program is devoted principally to research leading to the doctoral thesis. However, the student is encouraged to begin research as early as possible in his program of study.

Upon entrance to the doctoral program, each student is assigned an advisory committee. This committee is appointed by the Director of the Graduate School, based upon recommendation by the Chairman of the Division of Chemistry and Applied Chemistry, and consists of at least three members of the faculty. Of these at least two must be from the faculty of the Division of Chemistry and Applied Chemistry. One member of the committee representing the student's major field of interest serves as temporary chairman. After the student has selected his thesis supervisor, the temporary chairman of the advisory committee is replaced by the thesis supervisor, who then serves as permanent chairman.

Examinations

Qualifying Examinations—Three written qualifying examinations are given by the Chemistry Department, each involving one full day. These examinations cover the fields of organic chemistry, physical chemistry, and inorganic-analytical chemistry. Before the student can be admitted to candidacy for the doctorate, he must pass all three examinations.

Qualifying examinations are given in all fields twice each year, in September during or before the week of registration and in June following the final examination period. All three qualifying examinations must be attempted not later than the beginning of the third semester of graduate study in the doctoral program (normally in September of the second year), though any one or all may be attempted earlier. In cases of failure, re-examinations may be taken only during the June period. A second failure in any one of the examinations results in automatic dismissal from the doctoral

program. All qualifying examinations must be passed before the beginning of the third year in the program.

The comprehensive examination is in two parts, a written examination lasting one day and covering the field of the major, and an oral examination in defense of a proposition.

The written examination is given once a year in September. It should be taken as soon as possible after completion of the bulk of course work in listed graduate subjects in the field of specialization. However, it must be taken not later than the beginning of the fourth year of study in the doctoral program. Where it is necessary to carry less than the normal credit load of 12+ per semester, the student must apply for extension beyond this deadline to the chairman of the division through the chairman of his advisory committee.

Comprehensive Examinations—The comprehensive examination consists of two parts: a written examination and the oral defenses of a proposition. The written examination is scheduled for one full day and encompasses the entire field of the major. The oral examination on the proposition is directed primarily to the research topic submitted but may include relevant background material.

The proposition represents a thesis in miniature without laboratory work. With the aid and advice of his advisory committee the student selects a subject suitable for investigation, completes a literature survey, outlines the method of approach, and suggests possible results and conclusions. He is then required to defend his proposition by oral examination. The examination is conducted by the student's advisory committee and with other faculty members of the department in attendance.

Prior to the oral examination and at least one month before the scheduled date of the written comprehensive examination, the student must file with the chairman of his advisory committee three written copies of his proposition, presented in the form generally prescribed for a thesis. The oral defense of the proposition is presented after the written comprehensive examination, and permission to take the oral examination is contingent on first passing the written test.

The request to take both qualifying and comprehensive examinations must be initiated by the student. The request is made to the advisory committee, and the chairman of that committee then submits a written recommendation to the division chairman that the examination be given. The examination schedule is published well in advance of the date set, and the student must file the request with his advisory committee at least one month before the scheduled date. The deadline normally is 5 P.M., May 1, for the June examinations and 5 P.M. on the last day of classes in the second semester for the September examinations.

Thesis Examination—Upon completion of his doctoral research, the candidate must present himself for oral examination on his thesis. Permission to take this examination must be sought through the advisory committee chairman to the division chairman and is granted only after all candidacy requirements have been met and the comprehensive examinations passed.

Language Examinations—A candidate for the doctorate must demonstrate by examination ability to read technical literature in two foreign languages. One foreign language must be German. The second language is generally French or Russian. Proficiency in English is a requirement for foreign students, and the department reserves the right to establish this proficiency by examination if such action is indicated.

Language examinations are scheduled in November and in March. The student must present himself for examination in at least one language at each scheduled examination period until the complete language requirement has been fulfilled.

Course Offerings and Distribution

As a basis for the candidacy examinations the following core of subjects is recommended for the first-year students in the doctoral program:

CH 423-424*	Advanced Organic Chemistry	(3-0)	(3-0)6
CH 431-432*	Advanced Physical Chemistry	(3-0)	(3-0)6
CH 443-444*	Advanced Inorganic Chemistry	(3-0)	(3-0)6
CH 564	Organic Qualitative Analysis		(1-6)3

If results from the diagnostic examinations indicate adequate background in any of the above subjects, substitution by a more advanced subject in the 500 series is recommended. Full graduate credit is allowed in the 400 subjects listed above, but credit is not allowed in advanced 400 subjects representing the field of the major, even though these may be recommended. Additional subjects in chemistry or in the field of the minor may be taken in the first year if desired, provided the prerequisites are met.

In the second year, subjects supporting concentration in specific fields are available as follows:

Organic Chemistry

CH 513	Chemical Applications of Spectroscopy and Spectrophotometry		(3-0)3
CH 514	Physicochemical Methods		(2-0)2
CH 521-522	Physical Organic Chemistry	(3-0)	(3-0)6
CH 527-528	Stereochemistry	(3-0)	(3-0)6
CH 561-562	Advanced Organic Synthesis	(2-0)	(2-0)4
CH 565	Metal-Organic Compounds		(3-0)3
CH 566	Heterocyclic Chemistry		(3-0)3

The core of subjects recommended for majors in organic chemistry includes CH 521-522, CH 527-528, and CH 561-562. Majors in organic chemistry must also meet a requirement in physical chemistry comprising the course sequence CH 539-540 and CH 537.

Physical Chemistry

CH 531-532	Chemical Thermodynamics	(3-0)	(3-0)6
CH 533	Statistical Mechanics for Chemists		(3-0)3
CH 534	Quantum Mechanics for Chemists		(3-0)3
CH 535-536	Advanced Topics in Physical Chemistry	(3-0)	(3-0)6
CH 537	Chemical Kinetics		(3-0)3
CH 538	Rheology		(2-0)2
CH 539-540	Theoretical Chemistry	(3-0)	(3-0)6

Seminar

During each year of residence the student is required to attend and to participate in CH 507-508, Chemistry Seminar, (1-0) (1-0)2.

Majors and Minors

Students may major in organic chemistry or in physical chemistry. The prospective candidate, moreover, is expected to supplement his training in the major field of interest by electing a minor. To avoid overspecialization, this minor is normally selected in a field other than chemistry, although it may include polymer science. The minor may be divided between two fields and should represent a minimum of 12 credits.

Students wishing to minor in polymer science may select subjects from the following offerings:

CH 503-504	Chemistry of High Polymers	(3-0)	(3-0)6
CH 523	Stereochemistry of Macromolecules		(3-0)3
CH 524	Organic Chemistry of Macromolecules		(3-0)3
CH 551	Physical Chemistry of Macromolecules		(3-0)3
CH 552	Polymer Physics		(3-0)3

DOCTOR OF PHILOSOPHY DEGREE REQUIREMENTS

Term of Residence

Only work done during the regular academic year from September to June is counted toward residence credit. A minimum of one full academic year of study in residence is required of all candidates. A full year constitutes not less than 36 credit hours of work. Semesters in residence should be consecutive if possible.

All requirements for the doctorate must be completed within seven years after the student's entrance and within four years after admission to candidacy. Extension of time beyond this limit may be granted only with the joint approval of the student's advisory

committee, his department head, his division chairman, and the Director of the Graduate School.

Candidacy for the Doctorate

To be admitted to candidacy for the doctorate, a student must:

1. Complete the first year's core of advanced subjects in physical chemistry, organic chemistry, inorganic chemistry, and physicochemical methods and have a satisfactory record in undergraduate training, graduate seminar, and collateral reading.
2. Pass the qualifying examinations which test his general knowledge. One day each is devoted to an examination in the following areas: organic chemistry, physical chemistry, and combined inorganic-analytical chemistry.
3. Fulfill the language requirements.
4. Secure the approval of his advisory committee and the division chairman.

When these requirements have been fulfilled, the division chairman notifies the Director of the Graduate School in writing and recommends that the student be placed on the list of candidates for the Ph.D. degree. Admission to candidacy in no way guarantees the granting of the degree.

Requirements for Graduation

To be recommended for the Doctor of Philosophy degree, a candidate must:

1. Satisfy the residence requirements.
2. Pursue an approved program of study that includes the satisfactory completion of at least 90 credit hours beyond the bachelor's degree, or equivalent. At least half of these credits must be in formal course work exclusive of seminars or thesis.
3. Maintain at least a B— average in all work in formal subjects offered for the degree. The lowest grade acceptable for doctoral credit is C—. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work but which are taken during his enrollment as a graduate student must be passed with a grade of at least C—; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.

4. Demonstrate satisfactory reading ability in German and one other language (preferably French or Russian). Foreign students may under certain circumstances substitute their native tongue for one of these languages. Both language examinations must be passed prior to advancement to candidacy and before extensive work on the thesis is begun.
5. Pass the qualifying examinations for candidacy.
6. Pass the major examinations in the field of concentration. These examinations primarily test the student's knowledge in his special field of concentration and draw heavily on knowledge gained during his second full year of study in that particular area. They are given only when substantially all of the formal course work has been completed, normally at the end of the second full year (fourth semester). The major examination is in two parts. The first part is written and extends over a period of one day. It tests the student's broad knowledge in his specific field. The second part of the major examination is oral and tests the student's aptitude for research and his ability to organize and to develop a research problem. The examination takes the form of the defense of a proposition. The student selects a problem with the approval of his advisory committee.
7. Complete a satisfactory thesis. The doctoral thesis is designed to permit the student to demonstrate his ability to conduct original and independent research work. Results of the thesis investigation should constitute a definite contribution to knowledge in the field of specialization and should be suitable for publication. The field of the thesis investigation should be selected as soon as possible after admission to the graduate program, and the subject of the thesis must be approved by the advisory committee. As soon as the subject has been selected, the student must make his choice known to the department head, who in turn notifies the Graduate School so that the list of theses in progress may be kept current. The thesis subject must be filed not later than two weeks after the student has been admitted to candidacy. The thesis normally constitutes about half of the total credit requirement and, as a rule, requires three to four semesters of full-time work.
8. Pass a thesis examination. This is an oral defense of the student's thesis before the faculty of the Department of Chemistry.
9. Satisfy all requirements as to tuition and fees.





